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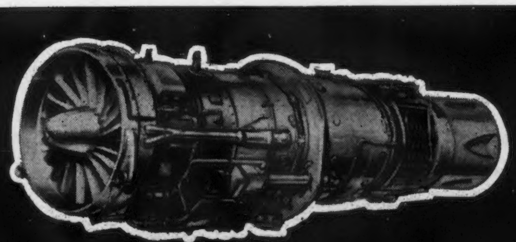

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CANADIAN AERONAUTICAL INSTITUTE

JOURNAL

SOME EFFECTS OF TIME AT TEMPERATURE ON 24S-T ALUMINUM ALLOY†

by J. A. Dunsby,* M.C.A.I.

National Aeronautical Establishment

SUMMARY

Experiments are described in which specimens of 24S-T aluminum alloy were held at temperatures of 400°F or 300°F for periods ranging from 1¼ to 100 hours, prior to conducting room temperature reversed bending fatigue or tensile tests. The physical properties of the material change radically with such treatments and it is shown that these changes can be correlated for varying times and temperatures by the use of the Larson-Miller parameter.

The results of the tensile tests are in good agreement with previously reported tests, provided that proper allowance is made for the initial condition of the material. It is shown that these earlier tests can be used to determine the effects of time at temperature on the tensile strength on a given sample of this material, provided that the initial yield strength is known.

INTRODUCTION

Many alloys of engineering significance require some form of heat treatment in order to give them the physical characteristics which make them suitable for practical applications. The heat treatment process may be of simple or complex form but frequently consists simply of heating to a certain temperature, holding at this temperature for a fixed time and then either cooling slowly or rapidly under controlled conditions. In more complex treatments, this heating and cooling cycle may be repeated for other times and temperatures; for example there is frequently an initial annealing cycle in which the temperature is raised sufficiently to remove the effects of any existing heat treatment and to reduce any residual stresses introduced during fabrication.

Variations in either time or temperature during the heat treatment process may result in large changes in the mechanical properties of a material and, consequently, the process is usually closely controlled in order to achieve optimum results. In service, however, there are frequently occasions when a component is either accidentally or deliberately overheated for short periods of time, thus modifying, in effect, the heat treatment process. The resulting effects on the properties are obviously of considerable interest to both the designer and the operator.

Most of the aluminum alloys are heat treated and their properties can be substantially altered by overheating even by small amounts. Examples of the effects of overheating on the tensile properties are tabulated in Reference 1 for a wide range of aluminum alloys, but, as far as can be determined, few data are available for the effects on other properties such as, for example, fatigue. The present experiments were therefore undertaken basically in order to obtain information on some of the effects of time at temperature on the fatigue properties of 24S-T3 alclad aluminum alloy.

As a secondary reason for the tests, there is much interest in the use of aluminum alloys at moderately elevated temperatures and, consequently, many experiments concerning elevated temperature fatigue, creep and so on are currently in progress. In conducting these experiments, the question naturally arises as to how long may be taken over stabilizing the specimen temperature before loading, if there is to be either no significant change in the material properties or any change is to be effectively complete. The results of the present investigation will be of assistance in resolving this problem.

†Paper based on N.R.C. Report MS-102.
*Associate Research Officer

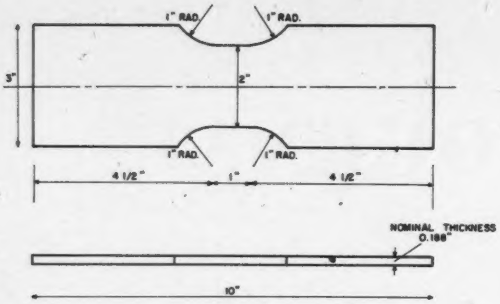

Figure 1
Nominal dimensions of specimens

SPECIMENS AND APPARATUS

The specimens were machined from 0.188 inch thick plate, 24S-T3 alclad aluminum alloy, to the profile shown in Figure 1. These specimens were, in fact, the residue from another, unreported, series of experiments conducted some years previously. Further reference to the age of the material will be made in the description of the results. In spite of the length of time for which the specimens had been stored, there was no evidence of any form of corrosion and the polished edges required no further treatment prior to the present series of tests.

The fatigue tests were conducted in a machine of the sub-resonant type, having a dynamic load capacity of ±1000 lb at a frequency of 1800 cpm. Standard four point loading fixtures were used to produce the required bending stresses in the specimen.

Tensile tests were also made on specimens identical to those used for the fatigue tests in a conventional tensile testing machine. Strain was measured in the tensile tests by the use of resistance strain gauges bonded directly to the specimen surface. These gauges permitted strain measurement well beyond the yield point of the material.

The time at temperature effects on the material were produced by soaking the specimens, six at a time, in a conventional laboratory oven, the atmosphere in the oven being air. Modifications were made to the temperature control system of the oven to permit closer control than is normally available. These modifications enabled the temperature of each specimen to be held within ±5°F of the desired value.

TEST RESULTS

The fatigue tests were all conducted in reversed bending and the first stage of the tests was to establish the basic S-N curve for the material as supplied in this loading condition. The results of these tests are plotted in Figure 2.

The criterion used for failure in these tests was that the machine should shut itself off owing to excessive specimen deflection. This generally occurred at the time of complete fracture of the specimen but, in six tests in the entire programme, the crack did not propagate completely across the specimen before excessive deflections occurred.

Five groups of six specimens each were then heated in the oven from room temperature to 400°F and held at this temperature for 100 hours. At the end of this period the oven was switched off and, with the door open, allowed to cool to room temperature. The heating and cooling cycles each occupied about 1 hour. Specimens were taken at random from these groups to produce a new S-N curve and three specimens were used to make tensile tests. The results of the fatigue tests are plotted in Figure 2.

In order to determine the rate at which the changes in fatigue life build up with time at temperature, five further groups of specimens were soaked in the oven at temperatures of 400°F and 300°F for times ranging from 1½ hours to 100 hours. Reversed bending fatigue tests were conducted on these specimens at an alternating stress of 22.5 ksi and a tensile test was also made on one specimen from each group. The stress level at which these fatigue tests were made was selected on the basis that it was one at which the differences in fatigue life obtained in the previous tests were large and, furthermore, the life was conveniently short. The results of these tests are plotted in Figures 3 and 4.

DISCUSSION

Figure 2 shows that the effects of the maximum soak time and temperature used in the present tests are quite large, resulting in a reduction in fatigue life which is greater than 40% at all stress levels. It also appears from the form of the curves that there is a substantial reduction in the fatigue limit, although unfortunately the limited number of specimens on hand did not allow a range of experiments sufficient to establish this reduction precisely. Accompanying these changes in fatigue behaviour, there is a large change in tensile properties, both the ultimate and yield strengths falling by about 20%.

Microscopic examination of representative specimens failed to reveal any marked change in the structure of the material, other than that the specimens which had received the longer times at the higher temperatures required considerably more time in the etchant to reveal the grain structure than did untreated specimens. Attention is drawn to this phenomenon in Reference 2.

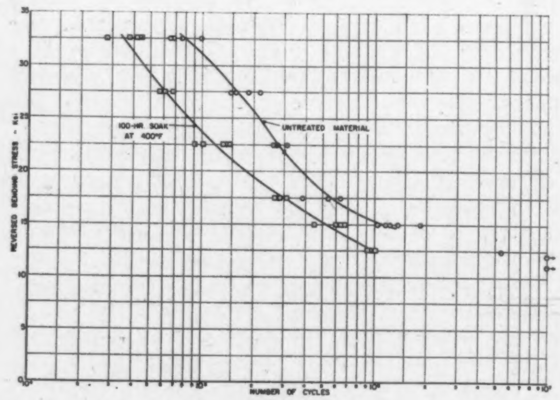

Figure 2
Effect of 100 hours at 400°F on room temperature S-N curve

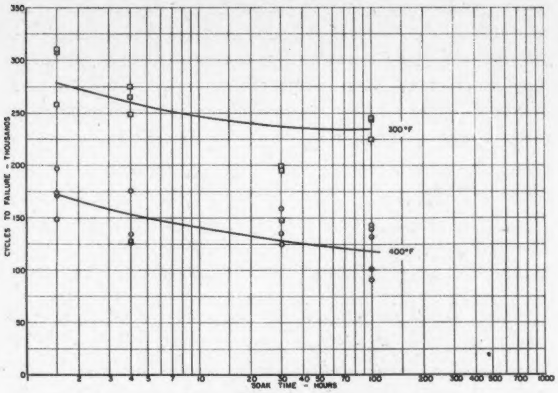

Figure 3
Effect of time at temperature on fatigue life at 22.5 ksi

The progressive deterioration in fatigue endurance with increase in soak time and temperature, shown in Figure 3, is emphasized by the use of a linear scale for the number of cycles to failure. Inevitably there is a certain amount of scatter to the test points and there appears to be some anomaly to the results obtained after soaking for 30 hours at 300°F. No similar effect is noticeable in Figure 4, which shows the results of the tensile tests on specimens heat treated concurrently with the fatigue specimens.

The changes in tensile properties show initially a large increase in yield strength accompanied by a smaller increase in ultimate. Subsequently, at 400°F, there is a large reduction in both yield and ultimate strengths. These strength changes are accompanied by corresponding changes in elongation, i.e., initially an increase followed by a decrease. The accuracy of elongation measurements is, however, insufficiently high to enable any close correlation with the strength to be made.

The ageing and overageing process is one controlled by diffusion and, as such, the rate at which it occurs is an exponential function of temperature. Two papers have been published[3, 4] which make use of this fact to produce a correlating parameter to combine the effects of time and temperature on the tensile properties of aluminum alloys. In essence, the argument used in deriving this parameter is that if a reaction rate r in a diffusional process follows the relationship $r = Ae^{-B/T}$ where A and B are constants for a particular material and process and T is the absolute temperature, then the same state in the process will be attained for a variety of times and temperatures if $T\ (C + \log t)$ = constant, where C is another material and process constant. This parameter is familiar, in the correlation of creep test results, as the Larson-Miller parameter.

Reference 4 makes use of this Larson-Miller parameter to correlate the effects of time at temperature on both the room and the elevated temperature tensile strengths of the two aluminum alloys, 2024-T3 alclad and 7075-T6 alclad. These are the US equivalents of the Canadian 24S-T3 alclad and 75S-T6 alclad, of which the former was used in the present tests.

The form of the parameter used in Reference 3 for the 2024-T3 is $T\ (20 + 1.3 \log_{10} t)$ where T is measured in degrees Fahrenheit absolute and t in hours, the constants being selected to produce the best correlation of the data. This, it may be noted, is very similar to the $T\ (17 + \log_{10} t)$ used in Reference 5 and elsewhere to correlate stress rupture data on this same alloy.

The results of this correlation are reproduced in Figure 5 while Figure 6 shows the data of the present investigation plotted on the same basis. The times used to evaluate the parameter plotted are those for which the specimen was at the soak temperature, and no allowance is made for the time at temperature during either heating or cooling. While this will introduce no serious errors when the soak time is long, it might be expected that for short soak times the error could be serious. In spite of this, with the exception of two isolated results, one for yield strength and the other for fatigue endurance, the Larson-Miller parameter appears to provide a good correlation of the test data. These two discrepancies are apparently due to the experimental scatter associated with tests of this type. Bearing in mind the fact that the tensile results are based on a single test point for each result and most of the fatigue results are for three tests only, the scatter is relatively small. The apparently small effect of the heating and cooling cycles is evidently due to the exponential variation of the ageing rate with temperature, which renders insignificant the

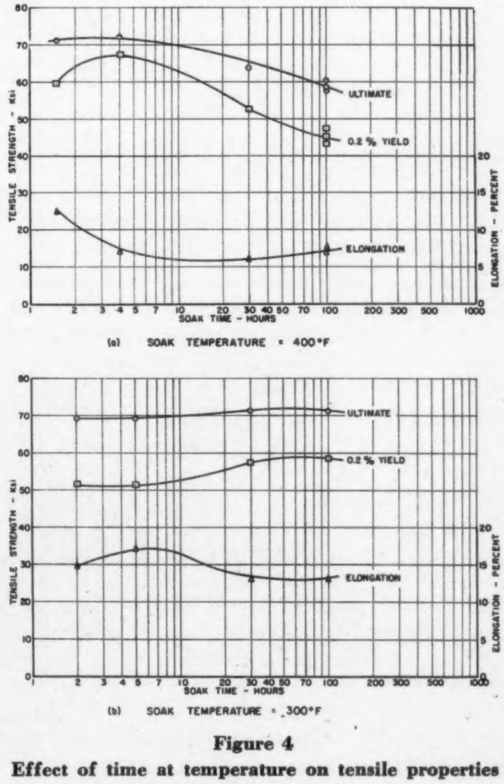

Figure 4
Effect of time at temperature on tensile properties

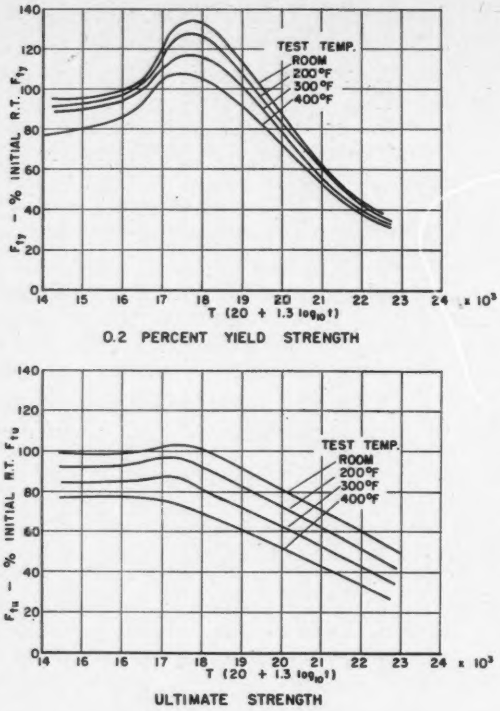

Figure 5

Effect of time at temperature on tensile strength of 2024-T3 alclad sheet[4]

effect of time at temperatures even slightly less than the soak temperature.

It is unfortunate that there is no overlap in the data for the tests at the two temperatures when plotted in the form shown in Figure 6, as this would provide a better indication of the validity of using the Larson-Miller parameter to correlate the fatigue data. Since, however, Reference 4 has demonstrated very clearly that the method is applicable to the results of tensile tests, there is little reason to doubt that this should also be true of the fatigue results and, to a large extent, this is supported by the present data.

Comparison of Figures 5 and 6 indicates that there are substantial differences between the behaviour of the 2024-T3 material used in the tests of Reference 4 and the 24S-T3 used in the present tests, for a given time at temperature. These differences will be shown to be due entirely to the extent of the initial ageing of the material, and the two sets of results can be correlated to a single curve.

It would seem evident that, for a given sample of this material, the most useful guide to the amount of ageing which has taken place is the yield strength, as this shows the greatest variation with time at temperature. The curves of Figure 5 have therefore been replotted in Figure 7 in terms of actual yield strength, rather than relative yield strength, using the initial value of 44.3 ksi quoted in Reference 4. The form of the Larson-Miller parameter has also been changed, from $T\ (20 + 1.3 \log_{10} t)$ to $T\ (16.67 + \log_{10} t)$, for convenience.

From Figure 7 it can be seen that for the material of Reference 4 to have developed the mean yield strength of 53.61 ksi found in the present tests, it would have been aged at a temperature and time such that $T\ (16.67 + \log_{10} t) = 13.1 \times 10^3$. Times and temperatures appropriate to this value are as follows:

T°F	t hours
100	9.5×10^7
200	2.75×10^4
300	6.77×10^1
400	6.65×10^{-1}

The times quoted above for the temperatures of 300°F and 400°F were added to those for which the 24S-T3 specimens were soaked at these temperatures and new values of the Larson-Miller parameter calculated for the tests. The results are also plotted in Figure 7. A similar comparison for ultimate strength is made in Figure 8. The agreement between the two sets of data is remarkably good, even more so when it is considered that the two batches of test material were made by different manufacturers at different times and in different countries.

Reference 6 contains further data on the effect of time at temperature on the tensile properties of a similar material, 2024-T4 rolled and drawn rod, and these have also been plotted on Figures 7 and 8. The agreement with the curves is reasonably good, al-

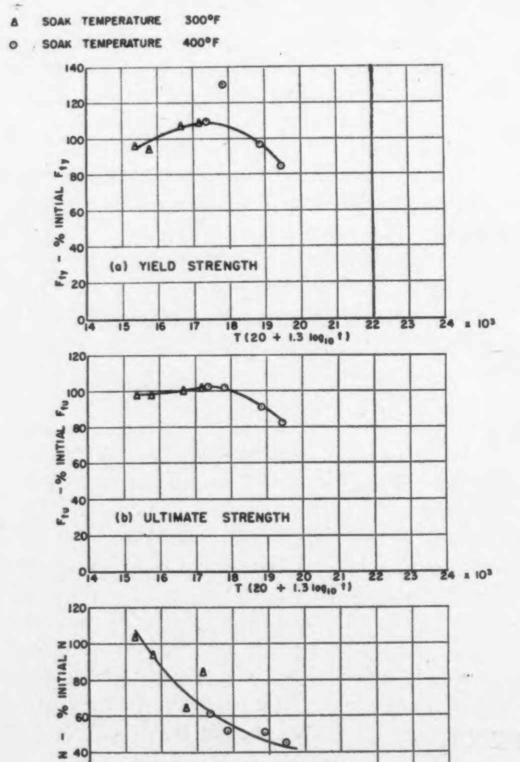

Figure 6

Correlation of data using parameters of Reference 4

though there is a suggestion that the curves may predict slightly smaller strengths at high values of $T\ (16.67 + \log_{10} t)$ than should be the case.

CONCLUSION

The results of the fatigue tests indicate that, as 24S-T3 aluminum alloy is progressively overaged, i.e., held at longer times for a given temperature or at higher temperatures for a given time, there is a continuous fall in fatigue endurance at a given stress. There are indications that the endurance limit also decreases. With the maximum time and temperature used in the tests, the fatigue endurance fell by amounts of 40% or more, depending on the particular stress level.

Accompanying the changes in fatigue properties, there are also changes in tensile properties. In contrast to the fatigue strength, however, the tensile strength initially increases. Subsequently both the yield and ultimate tensile strengths fall by substantial amounts.

The Larson-Miller parameter is a powerful tool in the correlation of the effects of time at temperature and appears to be equally applicable to tensile and fatigue as well as to creep results. In particular, the data of Reference 4 can be used to determine the effects of time at temperature on the tensile strengths of 24S-T and, by analogy, 75S-T, regardless of the initial condition, provided that the initial yield strength of the particular sample is known.

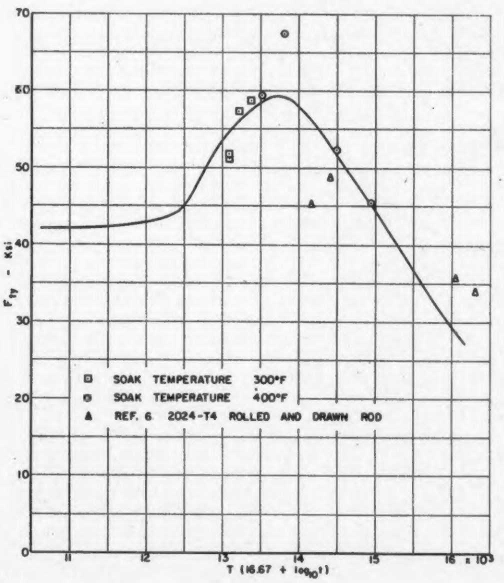

Figure 7

Yield strength vs Larson-Miller parameter derived from Reference 4 and comparison with data using corrected times

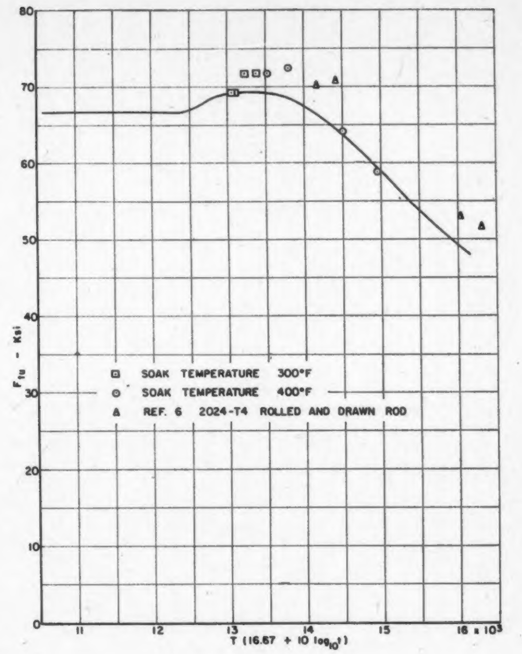

Figure 8

Ultimate tensile strength vs Larson-Miller parameter derived from Reference 4 and comparison with data using corrected times

ACKNOWLEDGEMENT

The work described has been carried out in the National Aeronautical Establishment, a Division of the National Research Council of Canada. This paper is published by permission of the Director.

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THE LOCKHEED BLC HERCULES — A PRACTICAL STOL TRANSPORT†

by F. N. Dickerman* and C. F. Branson**

Lockheed Aircraft Corporation, Georgia Division

SUMMARY

During the initial phase of flight testing of a C-130 Hercules airplane with complete blowing boundary layer control, the airplane demonstrated minimum flight speeds below 50 knots and takeoff and landing distances of approximately 600 ft at a gross weight of 100,000 lb.

The development program included studies of the various BLC systems, preliminary analyses of previous tests, a comprehensive wind tunnel program, a simple flight simulator and the flight test program directed toward demonstration of the airplane's performance.

The prototype has fully confirmed the feasibility of achieving STOL capability in a large cargo transport such as the C-130 Hercules.

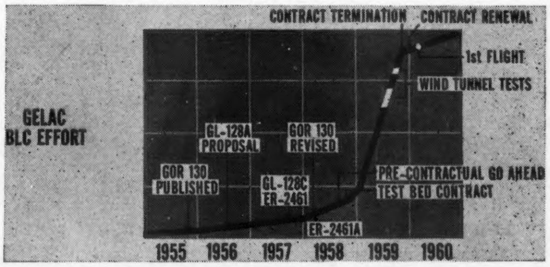

Figure 1
Development progress of the BLC-130

INTRODUCTION

The Georgia Division of the Lockheed Aircraft Corporation has recently completed the initial phase of flight testing a C-130 Hercules airplane with complete blowing boundary layer control. During the flight test program, the airplane demonstrated minimum flight speeds below 50 knots and takeoff and landing distances of approximately 600 ft at a gross weight of 100,000 lb. This development, which combines the effectiveness of blown flaps with deflected slipstream to reduce takeoff and landing speeds and achieve short takeoff and landing performance with a large cargo transport, is the subject of the ensuing discussion.

The standard C-130 Hercules is capable of takeoff and landing ground roll distances of approximately 1,500 ft on unprepared fields. Recognizing the tactical situations throughout the world and the advances in the state of the art, the US Army and Air Force came to feel that an assault transport should be capable of taking off and landing in much shorter distances. This thinking was crystallized in the Air Force General Operations Requirement 130[1] which specifies the ability to carry 20,000 lb of cargo on a radius mission of 1,000 nautical miles to a midpoint unprepared field with only 500 ft for ground roll available.

To fulfill this mission, Lockheed proposed a modification of the C-130 Hercules to include blowing boundary layer control on the flaps and all control surfaces. The purpose of the boundary layer control on the control surfaces was to provide adequate stability and control at the low speeds. The air for the BLC was to be supplied by bleeding four small jet engines hung on pylons under the wing.

The Lockheed proposal included design, construction and flight testing of a test bed BLC airplane, to demonstrate the capability of the complete boundary layer control concept in providing the performance, stability and control required for assault transport operation. To shorten the development time span, the test bed airplane was to use for BLC air two Allison T-56 load compressor engines, which were already available. In recognition of USAF interest in the proposal, Lockheed started precontractually on the design of the test bed in September of 1958. The contract for the test bed was awarded in October of the same year. The first flight was scheduled for December of 1959, one year later. Figure 1 shows the development progress of the BLC Hercules, from the initial studies through several versions of the BLC Hercules, known as the GL-128, and the test bed development to the final flight of the first phase in June of this year.

The design program for the test bed included comprehensive wind tunnel tests covering all phases of the BLC airplane operation. These tests provided data for a thorough analysis of the performance, stability and control of the test bed and production airplanes. By comparison with the flight test data, experience was gained on the effects of scale and tunnel walls on wind tunnel tests of BLC and deflected slipstream aircraft.

A simple flight simulator was constructed by connecting the C-130 full scale control system mock-up to an analogue computer. The simulator was used primarily for testing the stability and control of the test bed boundary layer control airplane.

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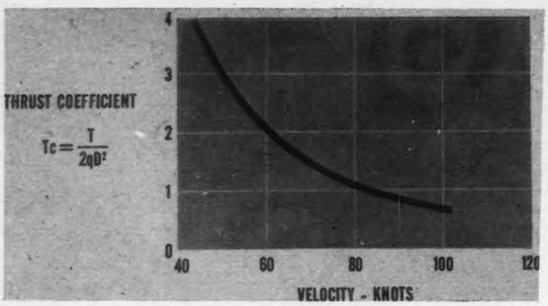

Figure 2
Thrust coefficient — maximum takeoff effort

Before the initial flight of the test bed airplane was made, budgetary considerations in the USAF necessitated the cancellation of the contract. However, Lockheed realized the potential of the BLC concept and provided funds for a minimum feasibility flight test program. This flight test program has now been successfully completed and showed the BLC Hercules to be a practical STOL cargo transport.

Initial studies by Lockheed of the effects of boundary layer control on the C-130 Hercules included both suction and blowing-type systems. Both systems were designed to prevent separation on the flaps and achieve higher maximum lift values. After an analysis of the systems and study of previous flight experience by the NASA, Lockheed and others, the blowing system was shown to be superior for the following reasons:

Blowing
(1) Greater $C_{L_{max}}$ due to supercirculation.
(2) Less liable to aerodynamic interference.
(3) Easier to manufacture than suction system.
(4) Simpler to apply to an existing airplane.

Suction
(1) Air horsepower approximately 50% of that required for blowing.
(2) System weight lighter than that for blowing.
(3) Severe maintenance problem on suction surface.

One of the primary advantages of the suction system is the lower power required, which, for the C-130, is approximately 50% of that required for the blowing system. Because of the decreased power for the suction system, the system weight was shown to be lighter than for the blowing system. The advantage of the blowing system is the higher maximum lift possible with additional air flow beyond that required to prevent separation. Since the boundary layer control system must be designed to operate satisfactorily in the event of a possible boundary layer control engine failure, there is additional capacity available above that normally required, of which the blowing system can take advantage. Joints, gaps and protrusions do not affect the blowing system to the same extent as the more sensitive suction system. Because of this and its location in the wing rather than in the movable surfaces, the blowing system is easier to manufacture. Finally, the porous surfaces of the suction system collect dirt particles that reduce its efficiency and create a maintenance problem. In summary, the application of boundary layer control to the existing C-130 airplane to achieve STOL performance is more effectively accomplished with a blowing system.

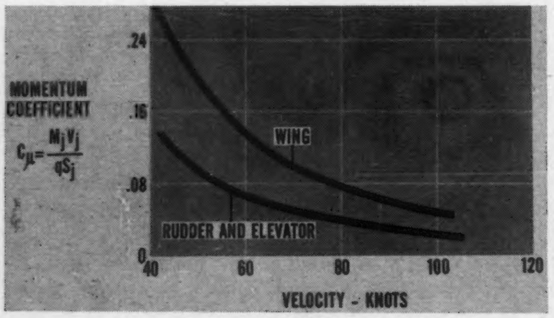

Figure 3
Momentum coefficient — maximum takeoff effort

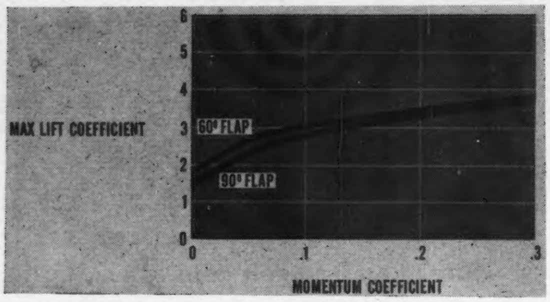

Figure 4
Effect of BLC flap on maximum lift coefficient
T_c = ailerons drooped 30°

AERODYNAMIC CONSIDERATIONS

To meet the requirements of a 500 ft airport established by GOR 130, it was necessary to achieve much higher maximum lift coefficients on the C-130 airplane. It was estimated that the required lift could be achieved by a combination of blowing boundary layer control and propeller slipstream deflection.

The maximum lift coefficient required for takeoff is approximately 7.0 at a speed of 50 knots. Figure 2 shows the variation of propeller thrust coefficient at takeoff power setting with airspeed for the BLC Hercules. Propeller thrust coefficient is defined by

$$T_C = \frac{\text{Propeller thrust of one engine}}{2 \times \text{Dynamic Pressure} \times \text{Propeller Diameter}^2} = \frac{T}{2qD^2}$$

At a speed of 50 knots, the thrust coefficient is 3.0.

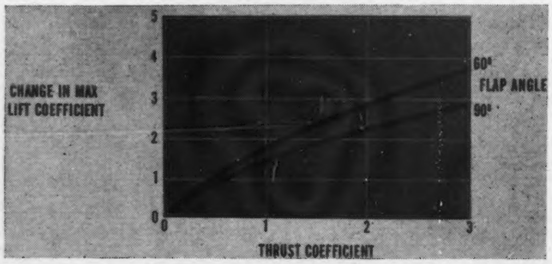

Figure 5
Effect of slipstream on maximum lift coefficient
$C\mu = 0.20$

The blowing coefficient varies with airspeed as shown in Figure 3. The blowing coefficients shown here are for the production airplane and are slightly higher than those available for the test bed airplane. The blowing flow coefficient is defined by

$$C_\mu = \frac{\text{Blowing air mass flow} \times \text{blowing airjet velocity}}{\text{Dynamic pressure} \times \text{area affected}} = \frac{m_j V_j}{q S_j}$$

The wing flow coefficient at 50 knots is 0.20.

On the basis of References 2 and 3, the variations of maximum lift with blowing and thrust coefficients were derived for the BLC Hercules. Figure 4 shows the power-off maximum lift for 60° and 90° of flap and 30° of aileron droop versus blowing coefficient. For the 60° flap deflection and a C_μ of 0.20, the maximum lift is 3.40. Figure 5 shows the additional maximum lift due to propeller slipstream. For a thrust coefficient of 3.0 corresponding to takeoff power at a speed of 50 knots, the increment in maximum lift is 3.80. The total maximum lift at 50 knots is 7.20, slightly greater than that required to provide the desired takeoff performance.

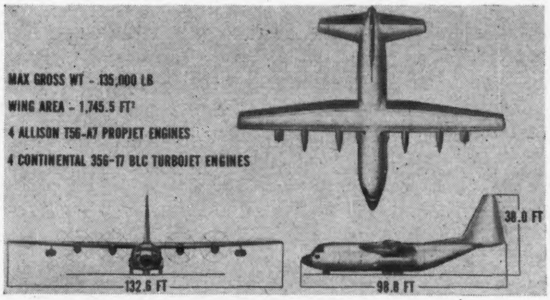

Figure 6
BLC-130 general arrangement

With the drag due to the much larger flap deflections possible with boundary layer control and the propeller slipstream deflection, the power settings during the landing maneuver are much greater than those normally experienced. For example, the BLC Hercules requires approximately 75% power for level flight with 90° of flap. From Figure 5, it is seen the propeller slipstream makes a substantial contribution to the landing maximum lift. The performance of the BLC Hercules is achieved, then, by the use of power-on stall speeds.

It was recognized early in the design of the BLC Hercules that the large thrust coefficients experienced would create stability and control difficulties. Experience on the C-130 had shown that, as power effect is increased to the maximum, stability in all three directions decreases to minimum levels, yet the maximum thrust coefficients on the BLC airplane are four times those for the C-130. The concept derived to provide satisfactory flying qualities despite low stability levels is the use of complete boundary layer control. Not only is boundary layer control applied to the flaps, but to ailerons, rudder and elevator also. On the rudder and elevator, it is applied to both sides. In addition to the use of boundary layer control, all surfaces have deflections approximately double those of the standard C-130.

TABLE 1
SURFACE DEFLECTIONS — C-130 AND BLC HERCULES

	BLC Hercules (deg)	C-130 (deg)
Flaps—T.O.	40	18
Landing	60	36
Ailerons—Droop	30	None
Up	BLC 30 Normal 30	25
Down	BLC 60 Normal 18	15
Elevator—Up	50	40
Down	39	15
Rudder—Right	60	35
Left	60	35

With the highly effective controls the following are possible:

(1) reduced minimum control speeds, with either a main propulsion engine or BLC engine inoperative, which are below the reduced liftoff and touchdown speeds,
(2) reduced nose wheel liftoff speeds below the takeoff speed,
(3) reduced minimum flare speed below the landing touchdown speed, and
(4) stabilized low speed flight using the control surfaces.

Highly effective controls are necessary for stabilized flight with neutral or negative stability whether an autopilot is used or, as on the BLC Hercules, the pilot flies the airplane. With reduced stability and airspeed, the response of the BLC airplane is slow compared with the human pilot reaction time. It was conceived that the pilot could conveniently fly the airplane in the same manner as a helicopter is flown or a car is driven.

Continuous small deflections would be required to provide the necessary stability. This becomes a practical consideration for the relatively short periods of operation in the BLC regime if, in addition, small control forces are used.

TEST BED AIRPLANE CONFIGURATION

The modifications to the C-130 to install boundary layer control are shown in Figure 6. A plain, hinged flap is substituted for the Fowler flap on the C-130 to simplify the BLC nozzle and duct design. All control surfaces are the same size as the C-130 except the rudder, which has been increased in chord 40%. All surfaces are aerodynamically sealed since leakage is more detrimental to control effectiveness with boundary layer control than for unblown surfaces. The deflections of the surfaces are much greater than for the C-130 as shown in Table 1. These flap deflections are those used during the flight test program of the test bed airplane. The production airplane is designed to use 60° for takeoff and 90° for landing.

One development contributing highly to the BLC design is the availability of small, lightweight turbine engines to provide the air required for boundary layer control. Table 2 summarizes the important characteristics of the currently available engines. All except the last three are bleed engines; the last three are load compressor engines with a separate compressor for

TABLE 2
SUMMARY OF BLC ENGINES

Engine	No. Used	Airflow for BLC lb/sec	Pressure Ratio for BLC	Weight lb
Fairchild J–83	4	15	3.7	400
G.E. J–85	4	18	3.8	325
P & W J–60	4.	15	4.1	530
Rolls-Royce RB 45	4	17.5	4.5	506
Bristol Viper	2	44	2.8	850
Continental 170	4	20	3.8	500
G.E. T–58	4	11	4.0	330
Allison YT–56–A–B	2	30	3.8	1672

BLC air. In an independent competition, the USAF chose the Continental engine for the production airplane. The Allison YT-56-A-6, however, was available for the test bed airplane and two of these engines were installed as shown in Figure 7.

The ducting system in the BLC airplane is shown in Figure 8. Boundary layer control is applied to the upper surface of the flaps and ailerons and to both surfaces of the elevator and rudder. The duct across the top of the wing is continuous with no valves that could fail and create an asymmetric lift condition. A typical cross-section of the ducts and nozzles is shown in Figure 9. The thin wall, stainless steel manifolds are insulated with impregnated fibreglas. If the manifold should rupture, the insulation can hold full system pressure. The duct, insulation, nozzle and surface skin are built as a unit in 5 ft long sections.

The duct sections are joined by simple V-type clamps. The nozzles are made of stainless steel welded to the duct, and are separated by streamlined spacers located approximately every 3 inches along the span.

The rudder and elevator, which have nozzles on both sides, have their airflow controlled by diverter valves, which direct the flow to the side opposite the deflection.

The flow over these surfaces varies from half flow on both sides at neutral deflection to full flow on the appropriate side at approximately 30° deflection.

The effects of propeller slipstream and boundary layer control flow provide erratic hinge moments on the surface. Because of this, a full power control

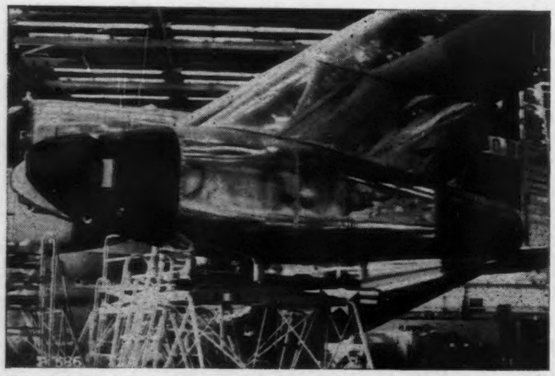

Figure 7
Test bed engine pod

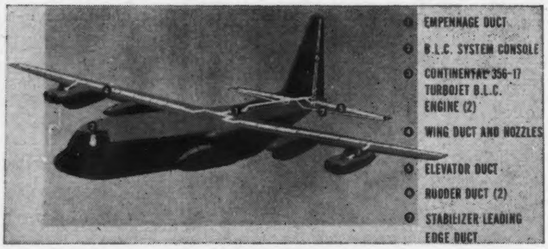

Figure 8
GL-128 BLC system

system is used on the BLC Hercules with artificially derived cockpit control forces. The full power system includes completely dual actuators, pumps and hydraulic lines. Only the single spool valve is common to both systems and it has dual orifices. A pressure reducer is included in the rudder system to limit deflections at high speeds. The reducer is actuated when the flap is 15° or less. All cockpit controls have approximately the same travel as for the C-130. As noted in Table 1, the aileron system includes a gear ratio changer which approximately doubles the aileron deflection per unit wheel deflection when the ailerons are drooped. Figure 10 shows the combination droop and gear ratio mechanism.

Because the total rudder deflection is 120°, a rotary actuator was designed for the BLC Hercules. Figure 11 shows a cross-section through the actuator. A high flow valve is used to overcome the effects of the relatively larger leakage of this type actuator.

The artificial feel system consists of simple, preloaded mechanical springs. The mechanical advantage of the elevator feel spring is varied by a dynamic pressure sensitive actuator to provide wheel forces at high speeds similar to those of the C-130 and good centering yet low wheel forces at low speeds. The test bed airplane which, for structural reasons, is restricted to speeds below 200 knots does not have the q-sensitive actuator. The control forces produced by the artificial feel system for the test bed airplane were originally comparable with the normal forces at maximum deflection, as given in the flying quality specification[4]. As a result of the flight tests of the airplane, these forces were reduced considerably, although they are still higher than the maximum forces for helicopter operation.

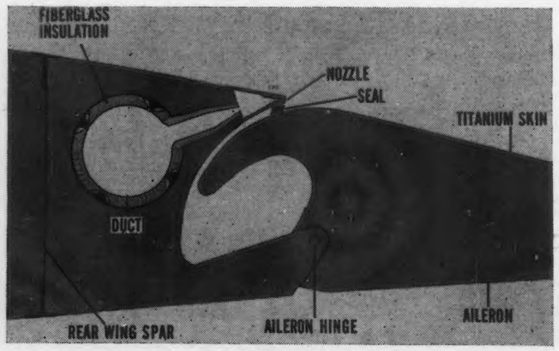

Figure 9
BLC duct — typical section

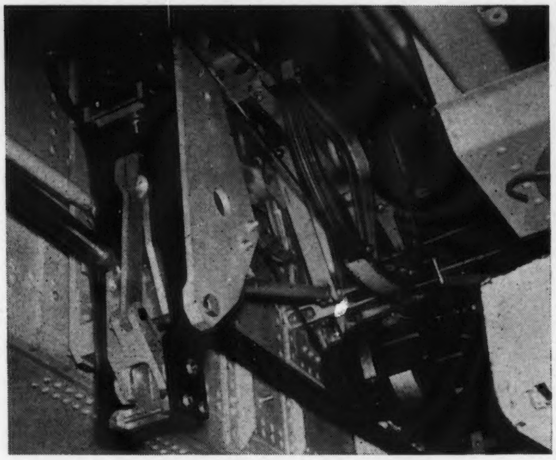

Figure 10
Aileron droop mechanism

WIND TUNNEL PROGRAM

A comprehensive wind tunnel program[5] was conducted on a one-tenth scale model of the BLC Hercules. The requirements for the wind tunnel program were based on the following:

(1) Critical nature of the stability and control of the BLC airplane.
(2) Need for data specifically applicable to the BLC Hercules configuration.
(3) Provide hinge moment data with blowing boundary layer control and propeller slipstream effects.
(4) Need for ground plane data.
(5) Provide wind tunnel data for comparison with flight test data to establish correlation procedures.
(6) Provide data with systematic variation of BLC and propeller slipstream effects.
(7) Provide control surface effectiveness data.
(8) Provide engine-out data.

The model was a complete one-tenth scale reproduction of the C-130 BLC airplane with electrically driven propellers and internally compressed air for boundary layer control. By having its own internal air source, the model was not subject to the large tare values resulting from bringing in outside air. Two small centrifugal blowers in the fuselage, driven by 660 hp electric motors, provided the blowing air. The model contained its own lubrication system for the blowers. Only electric power leads and cooling water were brought into the model.

The model was tested in the 18 ft subsonic wind tunnel at the United Aircraft Corporation, Hartford, Connecticut. Over 400 hours of testing were conducted covering over 800 different tests. The large number of tests were required to systematically cover the effects of blowing and propeller slipstream. For each standard run, 20 different runs were made to cover these variables.

Following Reference 6, the direct mechanical forces of the propeller and blowing thrust were subtracted from the measured lift data before these data were used to calculate upwash angles. The total drag force, including propeller and blowing thrust, was used to correct the dynamic pressure from the measured upstream value of the test section value.

The wind tunnel results showed the longitudinal stability reduction due to power effects was of the same order of magnitude as expected from the initial analysis. They also showed that, as expected, the trim shift due to flaps, power and boundary layer control helped to keep a stable elevator position versus speed curve — an essential item for successful flying qualities. The directional stability was not reduced by power effects, contrary to experience on the C-130, probably due to the large downwash. It was estimated the airplane would become unstable laterally due to spanwise shifts with sideslip of the lift due to propeller slipstream. The wind tunnel tests verified this estimate. Control effectiveness, as derived from a generalized procedure developed from the extensive blowing flap tests of References 2, 3, and 7, was closely substantiated by the tunnel tests. The maximum lift derived from the wind tunnel data adding the standard correction to full scale was slightly less than expected, based on Reference 2. The reason for this is not clearly known although it is probably a complicated scale effect.

A major problem arose from the wind tunnel tests in the form of a loss of elevator effectiveness due to horizontal tail stall at the lowest operating speeds of the BLC airplane. It was originally estimated that the airplane would be marginal in this area and the low Reynolds number of the wind tunnel tests reduced the maximum lift sufficiently to stall the tail and the large downwash angles obtained. After applying standard corrections to the horizontal tail maximum lift as derived in the tunnel, analyses showed that, with takeoff power and flaps at 60°, the full scale tail would still be stalled at speeds below 60 knots. Since the performance was based on achieving speeds of the order of 50 knots, this became a serious consideration. Two modifications were constructed to solve this problem. These were a permanent leading edge upward deflection of 30° with blowing at the base and a leading edge with blowing at 2% chord. The modifications were based on tuft studies which had shown the problem to be a leading edge stall. Additional tests were run showing either of these two would increase the maximum lift and the angle for maximum lift above those occurring for speeds below 50 knots. The blowing required was equal to that on the elevator.

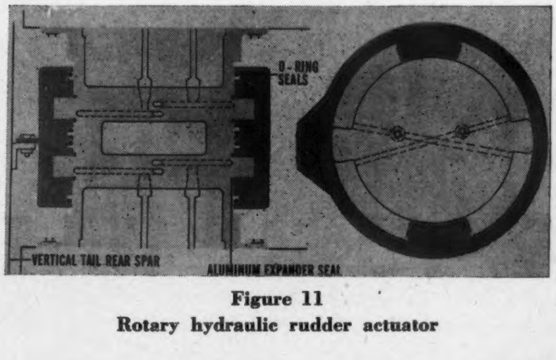

Figure 11
Rotary hydraulic rudder actuator

FLIGHT SIMULATOR PROGRAM

The thesis made in the BLC airplane design is that, despite neutral or slightly negative longitudinal stability and definitely negative lateral stability, the airplane can be satisfactorily flown with highly effective controls. The similarity to helicopter operation is apparent and natural as the speed is reduced toward zero. Little or no information was available on this subject even for variable stability aircraft. To test the thesis for a large cargo transport, a flight simulator was constructed simply by connecting the full scale C-130 control system to an analogue computer, which contained the equations of motion of the BLC airplane. Later, when the components were available, the control system was modified to the BLC configuration. Since the stability losses in both the longitudinal and lateral planes were due to power effects, the takeoff mode was chosen and the power set at maximum. The pilot then had control of the airplane through the wheel and rudder pedals, but the throttle was fixed.

The tests covered the takeoff from zero speed to 100 knots including ground effects and the liftoff. The control problems resulting from the following were studied:

(1) Wind gusts.
(2) Ground effect changes.
(3) Critical outboard engine failure.

The procedure was to make a takeoff and introduce a gust or engine failure at liftoff. Elementary cockpit presentation was shown. The following are the flight data for the pilot:

(1) Attitude – pitch and bank – oscilloscope.
(2) Speed – galvanometer.
(3) Rate of climb – galvanometer.
(4) Sideslip angle – galvanometer.
(5) Normal acceleration – galvanometer.

Various amounts of artificial stability were tried with some small improvement. The cockpit controls were standard C-130 components.

The equations of motion used for the analogue computer were the simple linear three degrees of freedom acceleration equations with the small angle assumption. An additional degree of freedom was added to each equation by freeing the controls. Their motion, of course, came to the analogue from potentiometers mounted under the simulator cockpit floor picking up the control movements. The airplane was assumed to be taking off from an unprepared field with fixed gear, flaps and power. Two recorders picked up the data on control positions, acceleration, airplane positions, control forces, airspeed and rate of climb.

Within the limitations imposed by its fixed position, the simulator showed that a large cargo airplane could be flown, although neutrally stable, with high control effectivity. The term "neutrally stable" is used to define the condition of the BLC airplane because of the slow response of the airplane. The C-130 autopilot with adjusted gains was used to fly the simulator with not very much more success than the human pilot. The long period and slow response is undoubtedly the major contributor to this result.

Since it is not planned to fly in the BLC regime for long periods of time, the attention required from the pilot is not considered a problem. Increasing the speed from 50 to 70 knots improved the handling characteristics of the simulator considerably.

FLIGHT TEST PROGRAM

The Lockheed funded flight test program was directed towards demonstrating the short takeoff and landing capabilities of the BLC airplane. Due to the design considerations discussed previously and the reliability of the basic C-130 airframe and engines, this program was successfully completed with 23 hours of test time, culminating in takeoff and landing demonstrations.

The flight test program consisted of these two basic parts:

(1) Slow speed flight with boundary layer control and power, including stalls to determine handling characteristics.
(2) Takeoff and landing performance.

The first part included handling characteristics with an outboard main propulsion engine or a BLC engine inoperative. Since the purpose of the program was to demonstrate performance, the weight and center of gravity were limited to median values of approximately 100,000 lb and 25%, respectively. A brief summary of the program is shown in Table 3. The 115 stalls, or approaches to stall, included the various flap deflections and power settings. 13 BLC takeoffs and 15 BLC landings were made. The program was completed 4½ months after the first flight.

The initial phase of the program was concerned with evaluation of the new full power control system and the artificial feel forces. The rudder rotary actuator was sluggish around neutral and required increased flow. The increased flow created an unstable system requiring dampers on the valve, which increased the rudder break out force to a value which is acceptable for the test bed airplane but not for operational aircraft. The aileron wheel forces were reduced to a maximum of 20 lb before they were considered acceptable. The elevator feel was produced originally by a q bellows in series with the wheel. The response of this arrangement proved unsatisfactory and a simple spring was substituted for the test bed. Since the test bed was structurally limited in speed, the stick force per g could be made acceptable.

TABLE 3
C–130 BLC FLIGHT TEST PROGRAM

First Flight	8 Feb. 1960
First BLC–on Flight	31 Mar. 1960
Total Test Time as of 22 June 1960	23 Hrs.
Total BLC Test Time as of 22 June 1960	19 Hrs.
Stalls	115
BLC Takeoffs	13
BLC Landings	15

All operation up to this point was without BLC. After considerable ground running to check the system, the first BLC-on flight was made on 31st March, 1960. Very rapidly the tests progressed to the point where full takeoff power stalls were being made. The stalls on the BLC airplane with power are characterized by wing tip stall outboard of the propeller. Due to the propeller slipstream no significant stalling occurs over the flap. With the tip stall, a corresponding decrease in aileron effectiveness occurs. This decrease in aileron effectiveness limits the minimum speed available. The pilot feels this decrease in the response of the airplane to aileron control input and breaks off the approach to the stall. During the approach to the stall there is a slight tendency for the nose to rise and, at the stall, the left wing tends to drop due to the relatively large effects of engine torque. The wind tunnel tests had predicted these stall characteristics and the estimated stall speeds reflected them. Figure 12 shows a comparison of the estimated stall speeds with those attained with the test bed airplane. These speeds do not include the airspeed position error correction, which would reduce them several knots since the airspeed calibration tests were conducted down only to 60 knots. The extrapolation was considered to be too far.

The problem of horizontal tail stall failed to develop during the flight test program. As a precautionary measure the up-tilted leading edge was installed to see what effect it would have on the airplane. However, it stalled on the upper surface with the low flap deflections used during the initial part of the program and it could not be reattached. It was then discarded in favour of the leading edge blowing slot. Thus far in the program, which has not attained the lowest speeds nor explored the forward center of gravity, the tail has not stalled and the leading edge blowing has not been required. There is a hand operated valve in the airplane to turn the blowing on and its effect has been checked several times with no noticeable change in the airplane.

The effect of the failure of a main outboard engine was considered at length in the design. The wind tunnel tests showed initially, and the flight test substantiated, that roll control would be critical since the minimum control speed becomes a three engine stall speed. The loss in lift behind the dead engine creates

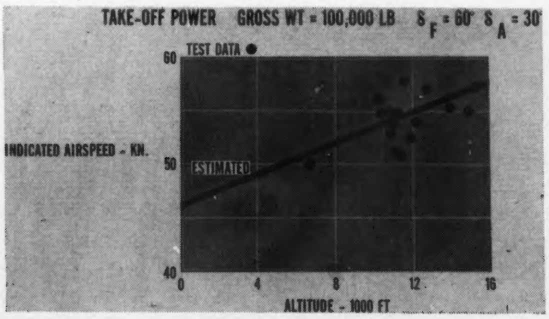

Figure 12
Flight test stall speeds

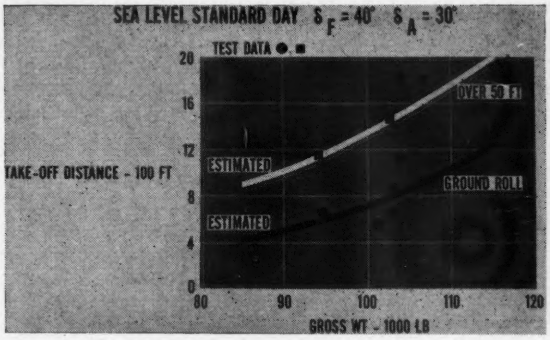

Figure 13
Flight test takeoff distances

an asymmetric lift that cannot be controlled by the ailerons. This speed is approximately 10% above the all engine stall speed. Assuming the three engine stall speed varies with altitude similar to the all engine stall speed, the minimum control speed at sea level is 55 knots.

The effect of a BLC engine failure was demonstrated to be very small. The BLC engine was cut at 70 knots and the speed reduced to 62 knots before the airplane stalled. Again applying an altitude correction would reduce this speed to 57 knots. Small trim changes were required when the engine was cut and adequate control was available down to the stall.

At flight speeds from 70 knots and above, control and stability are more than adequate. Low altitude flights with the ramp door open simulating aerial drop capability have been made at 70 knots with a flap deflection of 40°. Below this speed there is a gradual deterioration of stability until the airplane stalls. In this region, the pilot flies the BLC airplane with continuous small control movements in a manner similar to flying a helicopter. The low control forces were necessary in this region to reduce fatigue. As determined on the simulator, the pilot demonstrated with the airplane that he could control the flight path very well. The speed stability, that is, the ability to maintain airspeed, seemed much better on the airplane than on the simulator. The most important criticisms of the control system were the lack of centering and the loss in aileron effectiveness at the stall. Again the similarity to helicopter experience is apparent. The acceptable values of control break out force are influenced by the control force level and the stability of the aircraft. These criticisms were not serious however, and the flight test program had demonstrated that adequate flying qualities existed for flight at the low speeds required for short field takeoffs and landings.

The first step in making the short field takeoff was to determine the acceleration characteristics during taxi runs. Immediately, difficulty was experienced in keeping the airplane on the ground beyond 60 knots with 60° flap. The main gear lifted off and the pilot forced the nose wheel back on the ground. The airplane flew down the runway wheelbarrow fashion. Reducing the flap deflection to 40° increased the acceleration and reduced the attitude problem. Normal short field procedures were used except the airplane

accelerated during the climb-out. The results of the takeoff tests are shown in Figure 13 compared with the estimated data based on the wind tunnel tests. Despite the higher liftoff speeds experienced in the flight testing, the data show reasonable agreement. For a gross weight of 100,000 lb, the BLC airplane can get off the ground in 750 ft and over 50 ft height in 1390 ft.

The landing distance tests were set up to obtain the minimum ground roll distance. Standard short field procedures were used except the approaches were flat to utilize higher power settings and slower touchdown speeds. Figure 14 shows the test results compared with the estimated distances. The ground distance is 690 ft for a gross weight of 100,000 lb. The touchdown speed is 70 knots compared with an estimate of 65 knots. The pilot was able to obtain full braking and reverse thrust sooner than was estimated. These landings are made with 60° of flap. The use of 90° will require more power and can either reduce the air distances or decrease the touchdown speed and ground roll distance.

The BLC equipment worked exceptionally well during the flight test program. We experienced no difficulties with the main BLC ducts. The nozzles were adjusted once to even out the flow near the tips. Except for the q bellows, the feel and control systems worked satisfactorily. The production airplane will require very little in the way of detail system design change from the test bed, except for the BLC engines.

CONCLUSION

Further flight testing of the BLC Hercules will develop the following:

(1) Increased aileron effectiveness at the stall.

(2) More accurate low speed airspeed system.

(3) Decreased break out forces and improved control centering.

(4) Elevator control forces within specification requirements throughout the speed range.

(5) Landing procedures for minimum over-the-obstacle performance.

The test bed flight test program has demonstrated that the BLC Hercules is a practical STOL airplane. With the use of Continental engines for boundary layer control air on the production airplane, the flow is increased and the takeoff and landing distances are decreased to approximately 500 ft on an unprepared field as required by GOR 130. The complete boundary layer control system provides the stability and control required for assault transport operation.

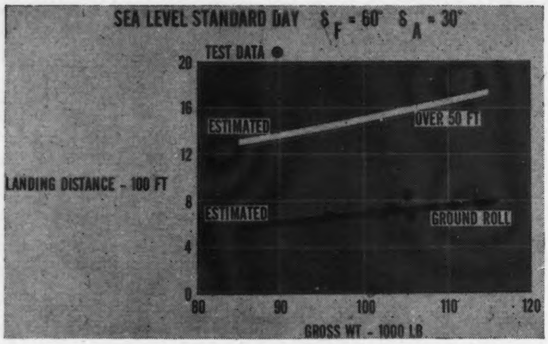

Figure 14
Flight test landing distances

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THE C.A.R.D.E. UPPER ATMOSPHERE RESEARCH PROGRAM†

by R. F. Chinnick,* A.F.C.A.I.

Canadian Armament Research and Development Establishment

SUMMARY

Investigations into certain characteristics of the upper atmosphere are being conducted at CARDE. A number of measurements have been carried forward and will be described. Further measurements using additional techniques are planned and will be briefly discussed. Methods of placing the instruments at altitude and instrumentation techniques used in the experiments will be described.

INTRODUCTION

OUR interest in the characteristics of the atmosphere is based on a requirement to understand the concentration and state of the various atmospheric constituents, in order that we may reliably interpret the effect of the atmosphere, or various layers of the atmosphere, on military equipment. The problem is being attacked initially by carrying out experiments to obtain the following information:

(a) the transmission properties of the atmosphere at various altitudes,

(b) the emission characteristics due to thermal and photochemical effects, and

(c) the concentration and state of the significant constituents of the atmosphere.

The initial investigations are centered on those atmospheric characteristics which contribute to absorption or emission in the spectral range from the visible to the infrared. Certain atmospheric species are known to contribute in a predominant manner in this spectral range, particularly in the lower atmosphere. These are water vapour, carbon dioxide, ozone, nitrous oxide and methane. At higher altitudes the effect of other constituents may become significant due to the relative increase in their concentration. Constituents such as hydroxyl (OH), nitric oxide (NO), sodium (Na), atomic oxygen (O) and other excited or disassociated species assume increased importance and interest.

CARDE is utilizing a number of measurement techniques in an attempt to add to the present fund of knowledge in this area, with particular emphasis on the characteristics of the Canadian atmosphere.

RESEARCH PROGRAM

Atmospheric absorption

Atmospheric absorption measurements at 40,000 ft have been made by Cumming[1, 2] from a CF-100 aircraft. The spectra were obtained using a sunseeker, a Perkin Elmer Model 108 spectrometer, a variety of detectors, associated electronics and a Consolidated Electrodynamics oscillograph recorder. A photograph of the equipment installed in a CF-100 tip tank is

†Paper read at the Canadian High Altitude Research Symposium in Ottawa on the 20th October, 1960.

*Superintendent, Electronics Wing

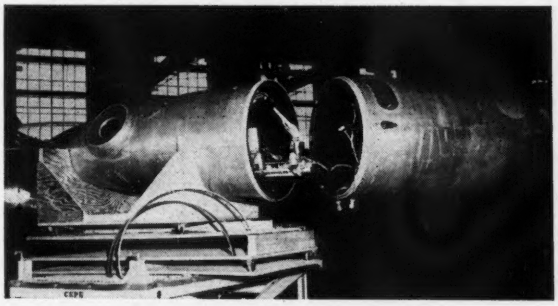


Figure 1

Instrumented CF-100 tip tank containing a spectrometer, sunseeker, recorder and associated equipment

shown in Figure 1 and typical solar spectra are shown in Figure 2.

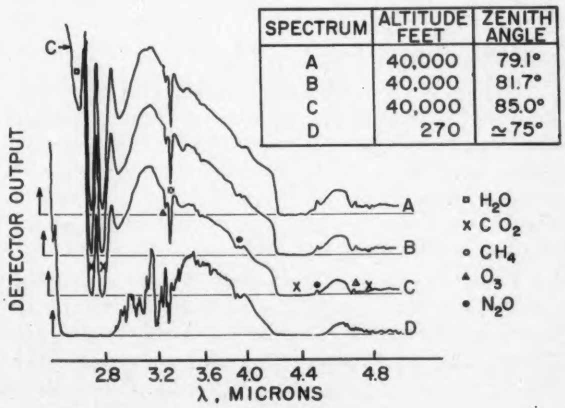
From this data, and applying the laboratory investigations at Ohio State University by Howard, Burch and Williams[3], an assessment of the CO_2 and H_2O content can be made. A typical result gives 255 ± 35 atm cm of CO_2 and $0.5 \pm 0.2 \times 10^{-4}$ pr cm of water in the zenith above 40,000 ft for measurements taken on the 12th November, 1958.

Atmospheric emission

Balloon measurements

Atmospheric emission spectra have been obtained with a balloon borne spectrometer at altitudes up to 100,000 ft.

The spectrometer utilized a 6 inch × 6 inch grating with 2500 lines per inch, a liquid nitrogen cooled, gold doped, germanium photoconductor and the associated electronics to amplify the photoconductor out-



SPECTRUM	ALTITUDE FEET	ZENITH ANGLE
A	40,000	79.1°
B	40,000	81.7°
C	40,000	85.0°
D	270	≃75°

Figure 2

Typical solar spectra obtained from CF-100 instrumentation

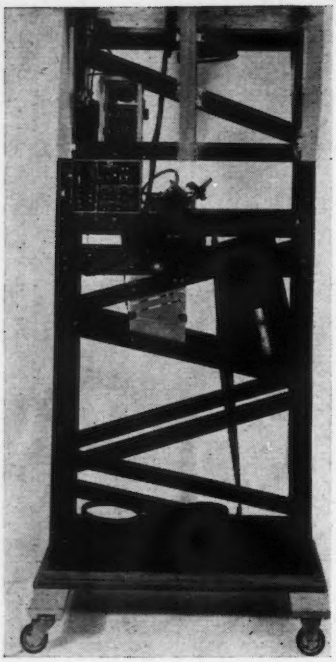


Figure 3
Gondola for balloon borne measurements. Covers removed showing construction, electronics, optics etc

put, record the grating position, ambient temperature, gondola orientation in azimuth and other pertinent data related to the experiment.

The spectrometer was designed by Harrison and Lowe[4] and the electronics were installed under the direction of Laflamme[5]. The complete gondola, housing the spectrometer and electronics, is shown in Figure 3.

Initial measurements have been in the region from 4 to 8 microns, and typical spectra are shown in Figures 4 and 5. From these data, the laboratory assessment of water vapour absorption of Howard et al[8], and the theoretical transmission curves for molecules obeying the Elsasser model, the water content can be measured. Calculations on the water content in the zenith above 38,000 ft using the data obtained on the 4th June, 1959, gives between 8 and 20×10^{-4} pr cm.

IGY measurements

Sodium-D and hydroxyl (OH) emission were measured in November 1958 using photometers and radiometers carried in a Nike-Cajun[6, 7]. The measurements were made in the altitude range of 40 to 140 kms. A photograph of the nose cone is shown in Figure 6, and the internal arrangement of the optical and electronic equipment is shown in Figure 7.

Two vehicles were launched, CC601 and CC602. CC601 was fired without the photomultipliers for measuring sodium-D emission, and the records indicated that the emission from OH was at or below the noise level of the system. CC602 produced useful data and Figures 8 and 9 indicate the resulting calculated distribution of sodium emission and hydroxyl emission for this experiment.

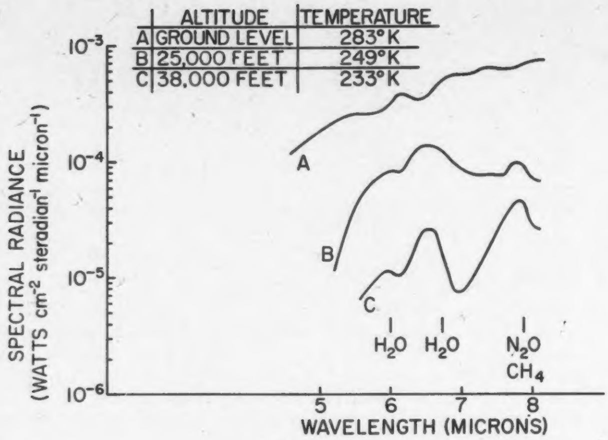


Figure 4
Typical atmospheric emission spectra for altitude from ground level to 38,000 ft

Chemical seeding measurements

Seeding of the upper atmosphere with nitric oxide released at an altitude of 100 kms will be carried out at Churchill, Manitoba, during 1960 and 1961. Nitric oxide is used to titrate for atomic oxygen, and an elaborate and complex group of instruments will be employed to measure the reaction effects[8].

FUTURE CARDE EXPERIMENTS

Atmospheric emission measurements will continue using the balloon borne equipment previously described. Additional programs are planned and will be briefly described.

Measurements of solar spectra to 100,000 ft

A gondola is presently under development which will carry a sun follower, an Ebert grating spectrometer and associated electronics for processing the information and telemetering the data to ground based recording instruments. With this equipment it will be possible to plot the concentration of water, carbon dioxide etc as a function of height to altitudes of the order of 100,000 ft. In addition, species presently masked by the still significant absorption of the H_2O and CO_2 bands at 40,000 ft may be revealed for analysis.

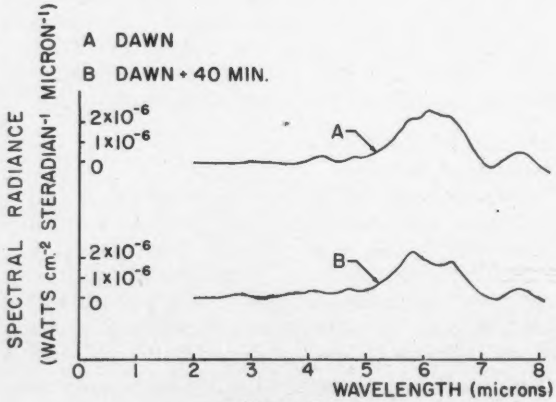


Figure 5
Atmospheric emission spectra at 90,000 ft

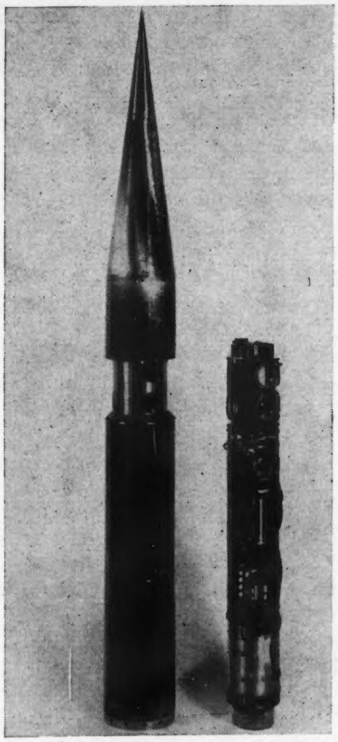


Figure 6
Nike-Cajun nose cone — left, the structural section and, right, the internal optics and electronics

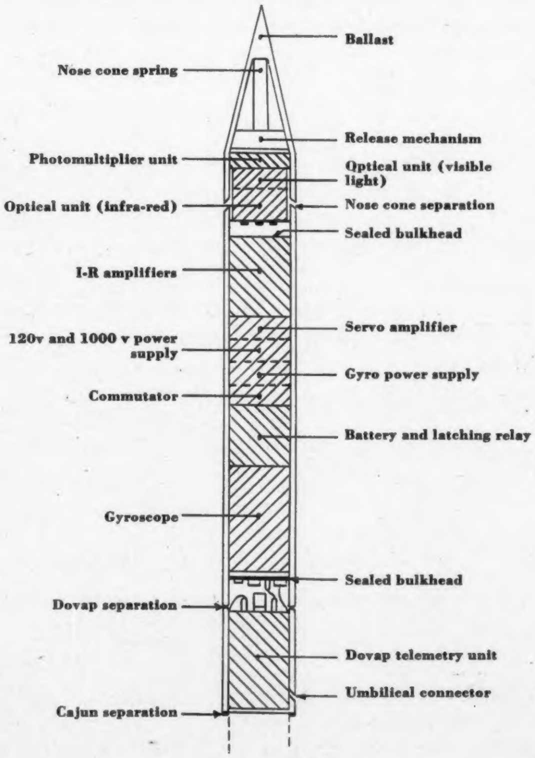


Figure 7
Layout sketch of the instrumented nose cone

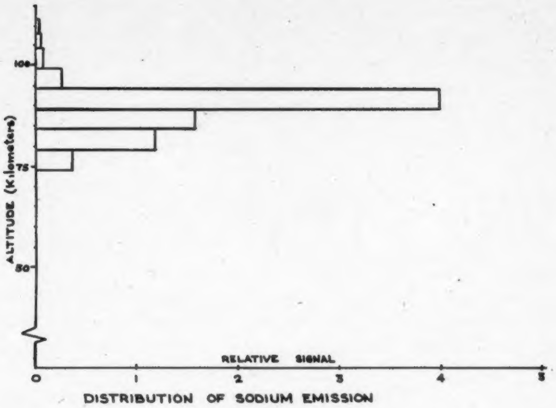


Figure 8
Relative distribution of sodium emission

Infrared radiometric measurements to 100,000 ft

Radiometric techniques for measuring emission spectra in the night sky are being developed at CARDE. At present a gondola is nearing completion which will carry a radiometer using two detectors (a gold doped germanium and lead telluride photoconductor), which alternately scan a sector of the sky, and a reference source (liquid oxygen) for calibration purposes. Much higher sensitivities are achievable with such a device than is available in our present spectrometer equipment, and as radiance at these altitudes is much reduced this is most desirable. Filters will be used to define the portions of the spectrum which are being measured. The detector outputs are amplified and the resulting signals telemetered and recorded on magnetic tape.

Microwave spectroscopy in the atmosphere

A further powerful tool in the study of the atmospheric constituents is microwave spectroscopy. By measuring the rotational resonance of molecules, either by absorption or stimulated emission, it is quite feasible to determine the concentration of a number of species. The application of this technique to measurements at high altitude has been studied at CARDE[9], and development of a balloon borne spectrometer is now in progress. A block diagram of the proposed instrument is depicted in Figure 10. Initial

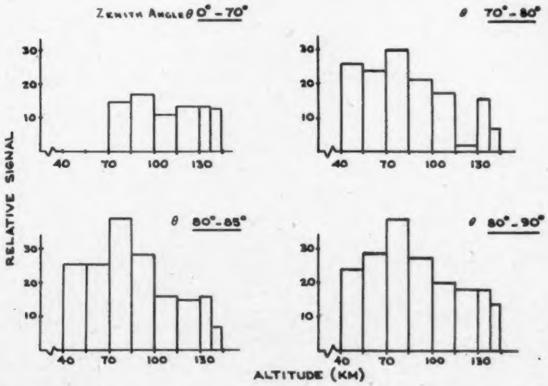


Figure 9
Relative distribution of hydroxyl emission

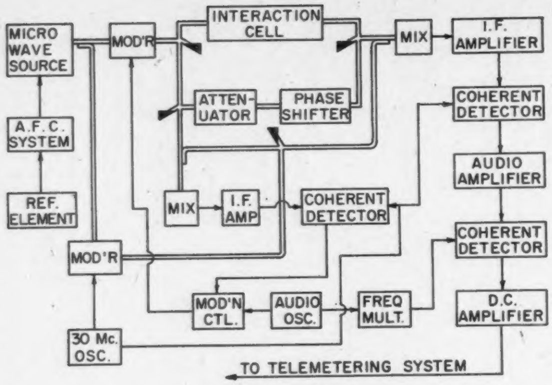


Figure 10

Block diagram of proposed microwave spectrometer. The interaction cell is open to the atmosphere

measurements are planned on the rotational lines of H_2O and O_3 using absorption measurement techniques.

COOPERATIVE MEASUREMENT PROGRAMS

A number of investigations are being carried out in cooperation with Universities.

Measurements on OH radiation, using the balloon borne spectrometer previously described and modified to operate in the 2 to 4 micron region, are being planned in co-operation with V. Jones of the University of Saskatchewan.

A further experiment to measure the vibrational rotational emission of the OH radical using a Michelson interferometer and the Fourier Transform Method has been proposed by H. Gush of the University of Toronto. This investigation will also utilize a balloon type platform and is planned for 1961.

Measurements on positive ion density concentration are being carried out with Black Brant vehicles in co-operation with P. Wilmore, University College, London, England. Spike probes complete with associated electronics to measure positive ion densities have been supplied by University College for installation in the CARDE vehicles to be fired at Churchill.

PLATFORMS

The methods used to place our instruments at the appropriate altitude are of interest and justify some comment. The more useful typical characteristics are compared in Table 1, which applies to the instruments and vehicles which have been used by CARDE in this program.

The figures quoted in Table 1 should not be construed as limiting values, as each platform is capable of a considerable range of performance depending on the total payload and the type of platform employed. Plastic balloons for example have achieved altitudes of 143,000 ft with a payload of 100 lb[10]. Such devices are available in a large range of sizes, with diameters ranging from 29 ft (11,000 cu ft) to 201 ft (3,000,000 cu ft) and material thickness from 0.003 inches to 0.00075 inches. The altitude performance of a given balloon system is related to the total weight of the system, and the type of balloon presently used at CARDE is illustrated by the top curve in Figure 11, which indicates a typical altitude versus total weight performance for this type of balloon.

While commenting on balloons, it is pertinent to emphasize the numerous advantages of this type of platform. These include large instrumentation payload capacity, ability to maintain instruments at altitude for very long periods, recovery of instruments for re-use and calibration checks, simplification of equipment design, and economy.

Rocket vehicles as platforms provide the increased altitude desirable in numerous experiments, and CARDE has utilized two types of rocket vehicles in its upper atmospheric studies, the Nike-Cajun and the Black Brant. The performance characteristics of the Nike-Cajun type vehicle have been thoroughly reported by Delisle, Hayes and Huva[11]. The CARDE developed Black Brant rocket has been described by D. Cameron[12].

INSTRUMENTATION

Instrumentation of the various experiments is extensive in that each experiment presents problems peculiar to that experiment. Nevertheless, a large portion of the instrumentation is quite similar, and these similarities will be covered to indicate the techniques utilized in experiments of this nature.

Telemetering

This technique is being employed in nearly every experiment, even those where recovery is fairly re-

TABLE 1

	CF-100 a/c	Balloon (128 ft dia.)	Rocket	
			Nike-Cajun	Black Brant
Operational Characteristics				
Altitude (ft)	40,000	100,000	475,000	350,000
Payload Weight (lb)	1,200	400	80	280
Approximate time for measurement	Over 2 hours	Several hours	Minutes	Minutes
Recovery	Yes	Yes	No	No
Data storage	Recorders on aircraft	Telemetering	Telemetering	Telemetering
Engineering and environment standards	Must meet aircraft safety standards	Sufficient to permit undamaged recovery by parachute	High g (50)	Medium g (20)

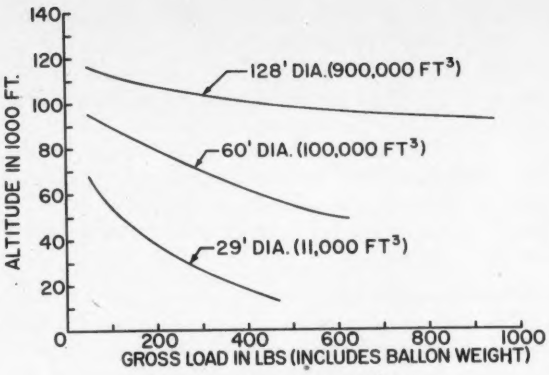


Figure 11

Load vs altitude for heavy load balloon based on helium lifting gas and NACA standard atmosphere

liable (such as balloon experiments) as it permits a large quantity of data to be transmitted and stored accurately and economically.

Two telemetering techniques are employed, FM/FM and PWM/FM. An FM/FM system consists of a number of frequency modulated oscillators (sub-carrier oscillators), operating with carrier frequencies of a few kc or tens of kc, driving a frequency modulated transmitter operating on a carrier frequency of 215 to 235 mc. The sub-carrier oscillators are driven by voltages from the transducer or measuring device. The PWM/FM system converts the voltage from the transducer or device into a pulse whose length is proportional to the voltage. By means of a commutator a number of voltages can be sampled in sequence. The resulting pulses are then applied to a frequency modulated or phase modulated transmitter operating on a carrier frequency in the same band (215-235 mc) as in the case of the FM/FM carrier transmitter. The detailed characteristics of these systems have been outlined elsewhere[13] and will not be reviewed here. The points of interest are as follows:

Input voltage: 0 to $\mp$ 5 volts or $-2\frac{1}{2}$ to $+ 2\frac{1}{2}$ volts.

No. of channels: FM/FM—Up to 14 channels with bandwidths between 75 and 2000 cps.

PWM/FM—A function of sampling rate; for 30 samples per second is 30 channels. (Further channels can be added by utilizing slow speed commutators, or by combining PWM systems with FM/FM systems.)

Sampling rate: FM/FM—as defined by the choice of a commutator and the sub-carrier oscillator.

PWM/FM—30 samples per second typical to 900 samples per second.

Output power: Approximately 3 watts in the 215-230 mc band.

Accuracy: 2% full scale.

Such equipment has proven reliable and satisfactory. Line of sight operation for distances of the order of 200 miles have been achieved on numerous occasions. Figure 12 shows a typical telemetering installation in a rocket nose cone.

Ancillary electronics

Many transducers used in such experiments are designed to operate with telemetering equipment. As a result the transducer output can be specified for the input voltages used in telemetry. Devices such as accelerometers, gyros, temperature indicators and pressure indicators fall in this category. However, the signals developed by the measuring instruments are in many cases very minute, and are not satisfactory for telemetering until amplified or processed in some fashion. For example, in the case of the balloon borne spectrometer it was necessary to amplify the spectrometer detector signal considerably, and consequently a transitorized unit with a gain of 500,000 and a dynamic range of 5000 : 1 was developed for this purpose.

In addition, circuits have been developed to convert the dc power from a common battery supply to the proper voltage and frequency to operate chopper motors, drive gratings, operate gyros and equipment designed to stabilize platforms or measure the attitude of the platform. Of interest in this respect is a stabilizing system designed at CARDE known as the "Big Wheel control system"[14] capable of maintaining the azimuth rotation of a given gondola at under 1°/sec.

Tracking aids

Information on the height and position of the experimental equipment is required for purposes of the experiment and to aid in recovery of the scientific equipment. Ground based radars are used for this purpose but are limited in range due to the limited radar cross section of the platform. To assist in the radar tracking of the system it is normal to employ beacons. These are in effect receiver-transmitters operating in the radar spectrum. A typical unit is capable of receiving signals in the order of −35 to −40 db and retransmitting a 50 to 100 watt pulse. The tracking radar range is thus considerably extended, in principle,

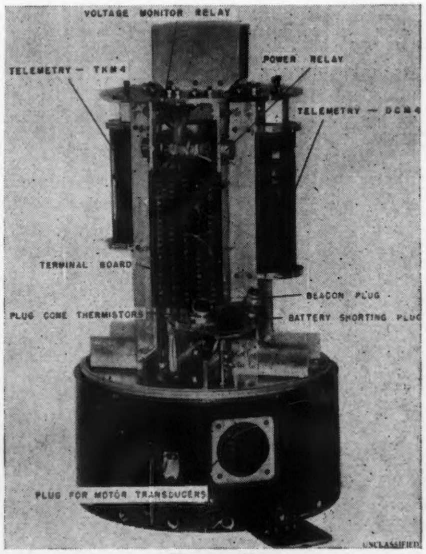


Figure 12

Typical telemetering installation in a Black Brant nose cone

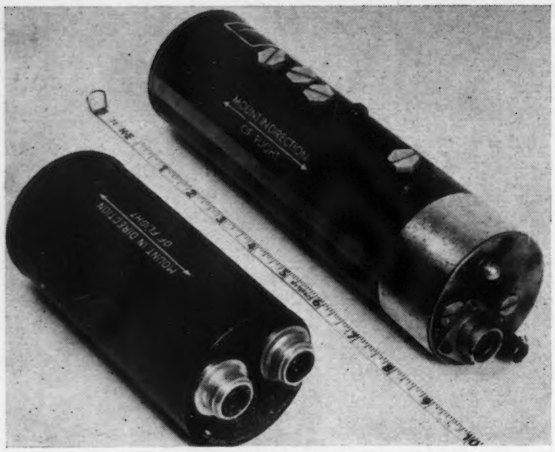


Figure 13
S band beacon for rocket installation — left, the beacon power supply and, right, the beacon transponder

to the order of 200 miles. Beacons are used by CARDE in aircraft, balloon and rocket experiments, and a typical beacon is shown in Figure 13.

In addition to beacons, a device known as a barracoder is carried in the balloon experiments. This consists of a barometric gauge operating into a transmitter on a frequency of about 2 mc. This unit has a dual function. Data is supplied continuously (once a minute approximately) on the barometric altitude, and the barracoder antenna acts as a continuous source of energy for homing with D/F equipment. In this manner aircraft equipped with a loop antenna and an appropriate radio compass or receiver can quickly locate the exact position of the gondola in the air and, of particular value, its location on the ground after cut down from the balloon. The barometric sensor and electronics of such a device are illustrated in Figure 14.

CONCLUSION

Successful measurements have been obtained on the following parameters:

(1) transmission characteristics of the atmosphere at 40,000 ft from 2 to 5 microns,
(2) telluric emission in the region 4 to 8 microns at altitudes to 100,000 ft,
(3) CO_2 and H_2O concentrations above 40,000 ft, and

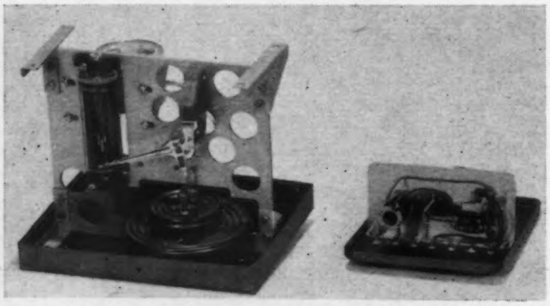


Figure 14
Barracoder for balloon experiments — left, the barometric sensor and, right, the transmitter

(4) OH (1.6 microns) and Na (6893 A°) emission profiles with respect to altitude.

The number of measurements obtained in the regions noted are as yet insufficient to permit a proper assessment of the atmospheric conditions due to diurnal and seasonal variations. Measurements of the type discussed will be continued and additional methods of investigation will be reviewed and considered in our search for a better understanding of the Canadian atmosphere.

ACKNOWLEDGEMENTS

The author is indebted to a number of scientific and engineering personnel at CARDE who are carrying forward the various techniques and programs described. The advice and co-operation of C. Winkler and H. Schiff (McGill), as well as those University staff members whose names are mentioned in the text, are most appreciated.

The support to these experiments by personnel and equipment of the Army and RCAF in flying equipment, launching and recovering balloon gondolas, and transporting and handling of rockets is gratefully acknowledged.

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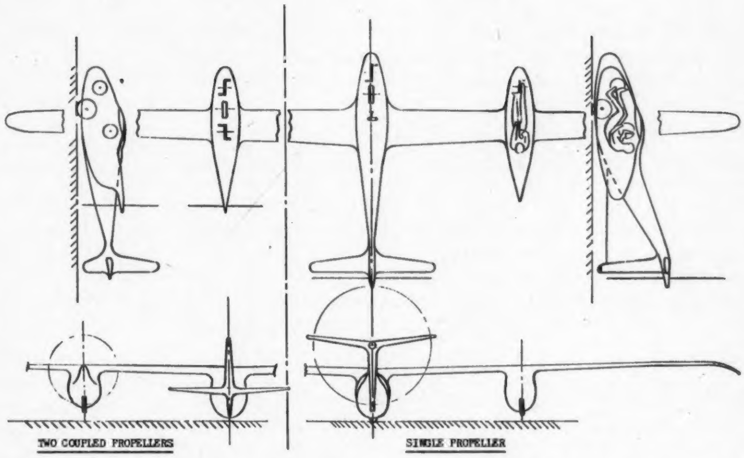
TECHNICAL FORUM

Man-Powered Flight

Although Mr. Haessler, in his very interesting observations on man-powered flight in the March issue, contends that the ideal crew for a man-powered aircraft is 1, others have argued that it should be 3, and I enclose drawings of two configurations which I believe to be well suited to the 3 man arrangement.



Two proposals for a man-powered aircraft to be propelled by three men

The 3 man aircraft proposed has the captain at the controls in the fuselage with the other crew members enclosed in pods or nacelles well outboard on each wing. Since the men contribute roughly $\frac{2}{3}$ of the all-up weight, by distributing their weights along the wing a significant reduction in structural weight should be realized. The power of all three men would have to be synchronized by means of a single cable drive. In the alternative arrangement, with all three men located in the fuselage, a more efficient transmission might be achieved but I believe that this advantage would be more than offset by the greater weight of fuselage and wing.

I have shown the craft with three wheels. Takeoff propulsion would be obtained by traction through the main wheel in the fuselage. I assume the wing would bend sufficiently to allow the outboard wheels, in the nacelles, to rest on the ground before takeoff and to become airborne during takeoff before the main wheel, as illustrated in the sketch.

The main wheel could be spiked and the outboard wheels replaced by skates for operation on a snow-bare frozen lake, the setting which I have long considered would see the first successful flight. A windless, moonlit night with sub-freezing temperatures, while the chosen lake rests in the centre of a high pressure area, completes the picture. Obviously there is but one fair land in the Commonwealth endowed by the Creator for the winning of the Kremer Competition.

Department of Mechanical Engineering,
Mississippi State University — W. G. Wells

(See Announcement on page 225)

BOOKS

VHF Line Techniques. By C. S. GLEDHILL. MacMillan Co., Canada, 1960. 60 pages. Illus. $2.50.

This handy pocket-size book presents a graphical method, based on the use of the Smith Chart, for the solution of many common transmission line problems. In addition to describing the solutions to specific problems, the theoretical basis of the chart is explained, thus making the book equally useful to the student and the practising engineer.

After a description of the Smith Chart and its development from well known formulae, a series of individual problems is treated, each being solved by both standard techniques and by the chart, to demonstrate the saving of time effected by the latter. The methods described, which the author feels are less generally known than they should be, could save hours of routine calculation and the book serves a very useful purpose by introducing them.

W. F. HAEHNEL

Energy Theorems and Structural Analysis. By J. H. ARGYRIS AND S. KELSEY. Butterworths, Toronto, 1960. 85 pages. Illus. $4.00.

This publication is a reprint of a series of articles written by Prof. Argyris in 1954-55 for *Aircraft Engineering*, supplemented by articles written in 1954 together with Mr. Kelsey, and is not intended as a textbook, which may explain a lack of the subject index and of a more complete list of references. The work of Prof. Argyris belongs to the period of the most spectacular development in aircraft design, shortly before the aircraft as a weapon became superseded by the ballistic missile. At that time the design offices of the aircraft industry received the most valuable gift ever bestowed upon an engineer; the electronic computing machine. Hence the work of Prof. Argyris no doubt stems from a realization that both the modern aircraft and the electronic computer demand a great deal more theoretical training from an engineer than was deemed necessary only a few years ago, and that a great gap is to be filled between the current practice of computing and various mathematical texts usually beyond the grasp of an industrial engineer. In this respect the work of Prof. Argyris makes fascinating reading and although about five years old is still unique, in particular in the part dealing with matrix calculus and the preparation of computer input.

At the beginning we meet various energy theorems: the principle of virtual work in terms of displacement and in terms of forces, the Castigliano theorems and the attempts to generalize these theorems to cover thermal effects and non-linear stress-strain relations. The consistent use of the Green transformation is appreciated very much by the reviewer. Approximate methods of stress analysis are reviewed with great clarity.

Then comes a long chapter on methods of analysis of structures with a finite number of redundancies. The chapter begins with an introduction to matrix calculus which is followed by a statement of the duality of the force and displacement methods. We meet many examples of the application of the theory to truss, frame and ring structures, and a thorough discussion of the redundant force concept. Subsequently the matrix force method is applied to multi-web structures, and the redundant stress systems peculiar to this type of structure are elaborated upon with greatest care. A detailed example of a two-beam tube closes the chapter. This portion of the work is especially good and should be pondered very seriously by all who leave universities with a good theoretical background but with perhaps little grasp of how to deal with practical problems.

The second part of the publication gives examples of the treatment of some thermal problems with non-linear, stress-strain relations and an approximate analysis of the torsion problem. The consistent application of the virtual work theorems makes this part a very valuable contribution to the approximate methods of stress analysis.

As concerns omissions, it is this reviewer's opinion that on page 40 and in the matrix (255) some off diagonal terms may be required to account for the coupling due to Poisson's ratio, in particular because the stiffness matrices on page 50 do contain this effect. This reviewer also feels that the oblique stress components have been given far too little attention.

DR. A. GRZEDZIELSKI

Nuclear Propulsion, EDITOR M. W. THRING, Butterworth, London, 1960. 300 pages. Illus. $9.50.

This book aims to set in proper perspective the hopes and problems of those seeking to exploit nuclear power for propulsion. Encompassing air, sea and space vehicles, the authors, under the editor, had a formidable task ahead of them. It is not surprising then that they could not succeed throughout to the same uniform level.

For the student, both young and old, a firm base in nuclear fundamentals is provided in the first two chapters. After this a treatment of gas turbine cycles follows rather surprisingly before studies on reactor characteristics. The problems of reactor design and control are covered in varying detail. The chapter on control gives the impression that none of the contributors were interested in this subject and a rather superficial chapter resulted.

The final part of this book is devoted to the commercial and military utilisation of nuclear propulsion. Even life on a space ship is considered!

In the technical content few errors other than very minor typographical ones are apparent and the text is well illustrated with figures which, in some instances, could have been better annotated.

The major criticism of this book is its lack of continuity and it is feared that the editor sought to cast his net too wide. Perhaps the title "Nuclear Propulsion – A Review of Selected Problems" would have conveyed the true nature of the book to the intending purchaser.

L. A. DICKINSON

C.A.I. LOG

SECRETARY'S LETTER

MAN IN SPACE

THE 12th April 1961 takes its place in history beside the 17th December 1903. After something like a million years of envying birds, Man finally got himself airborne in 1903 and, in little more than 57 years, he has climbed through the atmosphere and gone into orbit outside it. Such is the age in which we have been privileged to live; exciting times.

Though this new Russian achievement is supremely historic, personally I think the greater achievement was the launching of the first Sputnik on the 4th October 1957. That was the trick; the rest has followed in the course of natural development.

In my astrological make-up there seems to be some sort of relationship between my Satellite and my Toronto stars; they were in conjunction when I attended the unveiling of the Arrow on the 4th October 1957 and again when I had a meeting with the Toronto Branch Executive Committee on the 12th April 1961, to discuss the plans for the Annual General Meeting!

ANNUAL GENERAL MEETING

The Annual General Meeting proper – that is, the Business Session in the morning of the first day – is usually considered rather a dull affair and, in comparison with the technical sessions that follow it, it is usually very badly attended. This shows a regrettable lack of interest in the work of the Council, which has put in a good deal of time during the year for the benefit of the membership, and it also gives the incoming Council very little to guide them in the conduct of the Institute's affairs during the coming months. If those attending this Business Session are so few that they are not reasonably representative and if they do not get up and express their views on the Institute's many problems, the Council is working more or less in the dark, guided only by odd complaints and suggestions that come to my ears in the course of the season.

So I urge members to attend the Business Session on the 25th May. These sessions are never as dull as people expect them to be and, with all respect, I am sure that our President will put on a scintillating performance; he always does!

ADVANCEMENT IN GRADE

When a member is admitted to the Institute he is admitted to a grade appropriate to his qualifications at that time. These qualifications have two principal constituents, experience and professional performance. If a man makes fairly satisfactory progress in the course of his career, he will qualify for a higher grade with the passage of time. Some of the members who joined the Institute as Students in the early days have now progressed to the grade of Member; and this is as it should be.

I should like to make two points. Firstly, members should apply for advancement in grade whenever they feel themselves qualified; it is not automatic, because eligibility for admission to a higher grade does not depend entirely on time and, in any case, Headquarters records are not set up to keep tabs on the passage of years; the member himself must apply. Secondly, the applications must be made on a form, procurable from this Headquarters or from Branch Secretaries. I have been glad to see that a fair number of members have been applying for upgrading recently, but they have done so by letter and I have had to go back to them and explain about this form.

PILOTING EXPERIENCE

While on the subject of admissions, I should like to say something about a recent decision by the Council, which effects a minor but quite significant change of policy with regard to experience as a pilot.

In the past, when assessing an applicant's experience in, in the words of the Bylaws, "scientific, engineering, research, manufacturing or operational work in aeronautics", the Admissions Committee, on instructions from the Council, has given no credit at all for piloting, unless it has been in such fields as test flying and instruction, or in such highly responsible positions as airline captains and the like. This has resulted in some rather unsatisfactory grading in some instances; people of unquestioned standing in the profession of aeronautics have had to be assigned to relatively low grades or graded as Associates.

The Council has now agreed to give a more liberal interpretation to "operational work in aeronautics" to recognize time spent as a *professional* pilot, that is, as a pilot who makes his living by flying, in the assessment

of an applicant's qualifications. Of course to qualify for the grade of Member, the applicant must still have attained "recognized standing" – it will not be sufficient merely to have driven aeroplanes about the sky for eight years – and to become an Associate Fellow a pilot must have contributed to aeronautical science or engineering, whatever his standing in other fields.

In brief, there is no change in the Bylaws but the words "operational work" are now accepted as including professional piloting in any form.

This ruling may affect some of our existing members, making them eligible for advancement in grade or transfer from the grade of Associate to one of the technical grades. If so they should apply for their cases to be considered, using the Advancement in Grade form mentioned above.

BRANCHES

March seems to have been a month of tour speakers and I will arrange the following reports to deal with them first.

CDR J. F. Frank, RCN

Last November CDR Frank toured our western Branches, speaking on "The Technical Requirements for the Operation of Aircraft at Sea". He very generously offered to speak to any of the other Branches later and we took him up on it. He therefore spoke

in Ottawa on the 15th March,
in Montreal on the 22nd March, and
in Quebec on the 23rd March.

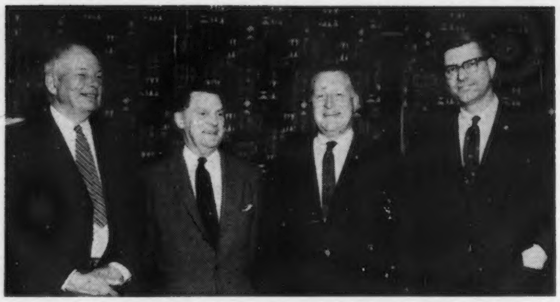
He introduced his talk with a short film, showing the launch and recovery of aircraft on a modern carrier, and then went on to describe the features of both ship and aircraft necessitated by this very exacting operation. There were only 41 of us at the Ottawa meeting – which means that many too many members missed a first rate lecture; there were 96 present in Montreal and, though I have no report from Quebec, I understand that the attendance there, in proportion to the size of the Branch, was the best of the lot.

Mr. W. S. Geddes, Canadair

Mr. Geddes, Manager of the Advanced Systems Planning Department of Canadair Ltd., visited

Vancouver	on the 20th March
Edmonton	on the 21st March
Calgary	on the 22nd March, and
Winnipeg	on the 23rd March.

Halifax-Dartmouth: LCDR G. M. Cummings, Chairman, presenting the Branch Student Award to Mr. J. K. S. Wong



Toronto: At the March meeting (l to r) Mr. P. C. Garratt, Managing Director of De Havilland Aircraft of Canada, Mr. C. H. Dickins, who introduced the speaker, Mr. W. Littlewood, and Mr. C. H. Bottoms, Chairman

His subject was "Advanced Systems Planning Looks at VTOL in Peace and War". I have no report from Edmonton, where, I understand, they have recently had the misfortune to lose their Secretary, but the other three have reported enthusiastically. As has so often happened this year, the attendances were disappointing – 33 at Vancouver, 36 at Calgary and 21 at Winnipeg – but the attendance does not always make the meeting, and I gather that those who did attend found Mr. Geddes' paper extremely interesting; from Vancouver, at least, Mr. Brechin reports a "very lively interest and question period".

We are greatly indebted to Mr. Geddes for making this trip. It is a pity that more of our members did not take advantage of it.

Quebec — 22nd February

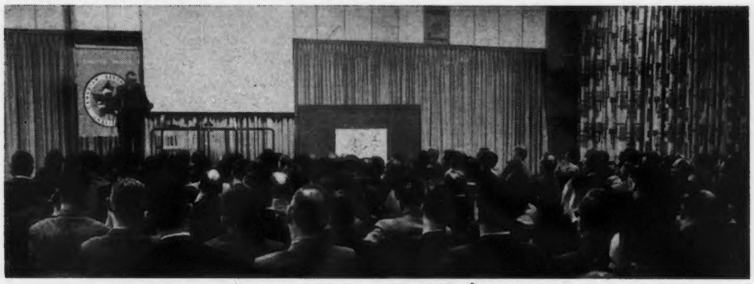
As a gesture of inter-Branch cooperation, the Halifax-Dartmouth and Quebec Branches arranged to supply speakers to each other this year. Mr. L. A. Dickinson of Quebec visited Halifax-Dartmouth on the 18th January, as reported earlier, and Mr. T. Howard Rogers, Officer in charge of the Defence Research Board Dockyard Laboratory at Halifax, visited Quebec on the 22nd February. He spoke on "Some Thoughts on Non-ferrous Corrosion". The meeting was held in Labatt's brewery – a fine Quebec Branch custom; Mr. Howard Rogers wrote to me after the meeting to express his appreciation of it. And it seems that the Branch enjoyed his talk, which he supported with a number of samples illustrating corrosion problems.

Halifax-Dartmouth — 15th March

The Halifax-Dartmouth Branch held its Annual General Meeting on the 15th March in the Nova Scotia Technical College. There were 29 present. The retiring Chairman LCDR G. M. Cummings, delivered the Annual Report, outlining a very successful year, despite a number of changes in the Executive Committee due to transfer etc. He then presented the Branch Student Award to Mr. J. K. S. Wong, an Honours Student of the Nova Scotia Technical College. The meeting concluded with the showing of three films, two on helicopter development and the third on air search and rescue methods.

Toronto — 21st March

The Toronto Branch had a very successful meeting in the De Havilland Cafeteria on the 21st March, when they were addressed by Mr. W. Littlewood, Vice-President, Equipment Research, of American Airlines – and, incidentally, an old friend of the CAI. Mr. Littlewood's



Mr. W. Littlewood addressing the Toronto Branch March meeting

subject was "Lockheed Electra 2 – An Analysis of the development leading to the new Electra". Approximately 280 members and guests attended.

Mr. Littlewood, using models, films and slides, described the intense investigation carried out on the Electra after two in-flight structural failures, and the modifications to the aircraft resulting from the findings; these comprise, in the main, a general stiffening of the engine nacelles and wing structure. His paper was followed by an interesting discussion from the floor. From all accounts, it was a meeting to be remembered.

Cold Lake — 29th March and 10th April

The Cold Lake Branch held a small business meeting on the 29th March. There was no speaker and most of the discussion was centred on the future development of the Branch.

This Branch has suffered a severe falling off in its membership during the last year, due entirely to its members being transferred away from the Station and no replacements coming in. In addition their evening meetings have encountered a good deal of competition from the other recreational activities of that isolated community. As a result the attendances at their evening meetings has been low – too low to make it worthwhile inviting speakers from outside.

They found a very good solution in their April meeting. They arranged for W/C K. R. Greenaway, Officer Commanding the Central Navigation School at Winnipeg, to come to speak to them and they got approval to hold the meeting during working hours and, in effect, for the meeting to be regarded as official. The meeting was held in the Station Theatre and, although attendance was entirely voluntary, 97 people attended. It was recognized as a CAI meeting; F/L N. H. Smith, the Branch Chairman presided; and generally it must have earned the Institute a good deal of favourable publicity.

W/C Greenaway's subject was "Airborne Radar Scope Interpretation".

Toronto — 14th April

The April meeting of the Toronto Branch was held jointly with the Canadian Astronautical Society, the Royal Astronomical Society of Canada and the UTIA. Dr. I. I. Glass was in the Chair and 185 people came to hear Dr. Samuel Herrick of the University of California in Los Angeles speak on "Astrodynamics and Space Navigation". As Mr. Kinsman observed in his report, this was a very timely subject, falling as it did two days after Major Gagarin's achievement, and it evoked a good deal of interested discussion. Evidently it was a very successful meeting – and, as I have often said, I think joint meetings of this sort are well worthwhile.

ANNOUNCEMENTS

ANGLO-AMERICAN CONFERENCE

The Eighth Anglo-American Conference will take place in London from the 3rd to the 14th September 1961. Attendance will be limited to members of the three participating societies, namely the Royal Aeronautical Society, the Institute of the Aerospace Sciences and the Canadian Aeronautical Institute.

The programme of the first week, from the 4th to the 8th will be devoted to plant tours and a visit to the SBAC Show at Farnborough. During the second week, from the 11th to the 14th, the programme will comprise a series of technical sessions in the Lecture Theatre of the Royal Aeronautical Society at 4 Hamilton Place. Papers will be presented on Supersonic Air Transport, STOL/VTOL and Space. Canadian papers will be delivered on the first two of these topics.

Registration

Members of the Institute planning to attend the Conference must register in advance and should apply to the Secretary for application forms. The Registration Fee is $35, which will include an order for a copy of the Proceedings.

Security

To participate in some of the plant tours it may be necessary to arrange security clearance. Advice on this point will be issued to those who register for the Conference.

Travel and accommodation

Members are responsible for making their own travel and hotel arrangements. They are advised to take steps as soon as possible, since accommodation on the trans-Atlantic air services and in the London hotels is liable to be heavily booked at that time of year.

Further details will be announced later.

SUSTAINING MEMBER NEWS

Avro Aircraft Limited has recently announced that it has taken over control of the Richardson Boat Co. of North Tonawanda, New York.

Richardson became associated with Avro last year when Avro started production of aluminum planked hulls for Richardson cruisers. Superstructures are built in North Tonawanda, and the announcement said the same procedure will continue under the new management.

NEWS OF MEMBERS

J. H. Parkin, Hon.F.C.A.I., formerly Director of the Division of Mechanical Engineering, National Research Council, recently received an honorary degree of LL.D. from the University of Toronto.

E. K. Brownridge, F.C.A.I., formerly Executive Vice-President and General Manager of American Motors (Canada) Ltd. has recently been elected President.

J. M. Bridgman, M.C.A.I., formerly Manager of Litton Systems (Canada) Ltd. has been appointed Vice-President and General Manager.

E. L. Bunnell, M.C.A.I., has recently been appointed Military Sales Manager of Field Aviation Company Ltd.

DEATH

It is with deep regret that we record the death of **J. R. Parbery, M.C.A.I.,** who died on the 8th March, 1961. At the time of his death, Mr. Parbery was an Operations Engineer with Canadian Pacific Air Lines, Ltd., Vancouver.

ADMISSIONS

At a meeting of the Admissions Committee, held on the 22nd March, 1961, the following were admitted to the grades shown.

Associate Fellow

W/C P. J. Bula
(*from Member*)

Member

LCDR H. J. Bird
(*from Associate*)
J. R. Bissell
L. J. Cook
A. B. Johnson
E. Juzak
H. W. Lawton
G. R. Lowe
F. Marshall
R. W. McIntosh
Dr. A. K. Ray
W. W. Roderick
F/L J. F. Snell
A. Sunne
G. H. Tidy

Technical Member

B. M. Fairey
J. O. Griffith
H. D. Johnson
J. R. Shekleton
F/O W. J. Singlehurst
A. C. Spode
F/O S. Kereliuk
F. Kisko
C. W. Naigle
(*from Junior Member*)
H. J. Runnalls
J. N. Swinsle
A. Thivierge
Sgt. W. B. Van Blaricom
D. L. Ward
N. Zotoff

Student

L. H. Moore
F/C J. A. M. Landry
T. H. Reyburn
R. A. P. Sweeney
J. K. S. Wong

Associate

C. G. Campbell
C. S. Wood

APPOINTMENT NOTICES

The facilities of the Journal are offered free of charge to individual members of the Institute seeking new positions and to Sustaining Member companies wishing to give notice of positions vacant. Notices will be published for two consecutive months and will thereafter be discontinued, unless their re-instatement is specifically requested. A Box No., to which enquiries may be addressed (c/o The Secretary), will be assigned to each notice submitted by an individual.

The Institute reserves the right to decline any notice considered unsuitable for this service or temporarily to withhold publication if circumstances so demand.

Box 121 **Student:** Second year student in Aeronautical Technology at the Ryerson Institute of Technology seeks position for the period May 1st to September 15th.

Box 122 **Professional Engineer:** M.C.A.I. presently undergoing post-graduate studies at university seeks position for the period June 10th to October 5th. Experienced in research, development, design and evaluation in aircraft and missile structures, propulsion, control instrumentation, hydraulics, heat transfer, jig and tool design etc.

COMING EVENTS

RAeS/IAS/CAI

3rd-14th September, 1961 – *Anglo-American Conference*, LONDON, ENGLAND.

IAS/CAI

23rd-24th October, 1961 – *Joint I.A.S./C.A.I. Meeting*, OTTAWA, ONT.

CAI

25th-26th May, 1961 – *Annual General Meeting*, TORONTO, ONT.

Sections

Astronautics

26th-27th October, 1961 – *Interplanetary Exploration Symposium*, TORONTO, ONT.

TIME FOR A SEARCHING REAPPRAISAL

In the light of current developments in air cargo, we challenge you to consider this statement. The time has come to make a searching reappraisal of air freight operations if they are being conducted with obsolete piston-powered passenger aircraft that have been converted for cargo. We are convinced that these aircraft, although they may still represent a multi-million dollar book investment, should now be disposed of, notwithstanding current market prices, and replaced by the modern all-cargo Canadair Forty Four. Inevitably, the disposal will result in a "profitable loss," because it can be shown that the Forty Four is the only all-cargo aircraft able to operate at a profit, either domestically or internationally, under the new low freight rates and will recover in a short period of time the losses incurred on the sale of the outmoded converted equipment. Any Canadair official would welcome the opportunity to discuss this in more detail.

CANADAIR
LIMITED, MONTREAL
FIRST IN THE WORLD OF AIR CARGO

Ad. No. CCT-61-1A